Report No. 24.

NINTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA 1928

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY

EDMONTON:
Printed by W. D. McLean, King's Printer
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ORGANIZATION.

The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

Chairman—Hon. J. E. Brownlee, Premier.

R. C. Wallace, President, University of Alberta.

Hon. O. L. McPherson, Minister of Public Works.

J. A. Allan, Geologist.

N. C. Pitcher, Mining Engineering.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

R. M. Young, Canmore, Alberta.

Honorary Secretary—Edgar Stansfield, Chief Chemical Engineer, Industrial Research Department, University of Alberta.

Requests for information and reports should be addressed to the Honorary Secretary, Industrial Research Department, University of Alberta, Edmonton, Alberta.

TABLE OF CONTENTS

UNIVERSITY OF ALBERTA,
EDMONTON, ALBERTA.

HON. J. E. BROWNLEE,
Premier,
Edmonton, Alberta.

Sir:—

Under instruction from the Scientific and Industrial Research Council of Alberta, I herewith submit their Ninth Annual Report. This covers the work done under their direction during the year ending December 31st, 1928.

Respectfully submitted,

EDGAR STANSFIELD,
Honorary Secretary.

NINTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

ORGANIZATION.

In the organization of the University of Alberta, the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research laboratories.

In the organization of the Provincial Government the work of the Research Council is attached to the Executive Council.

PERSONNEL AND MEETINGS OF COUNCIL.

Four meetings of the Council were held during the year. The personnel of the Council on December 31st was:

Hon. J. E. Brownlee, Premier, Chairman.

R. C. Wallace, President, University of Alberta.

Hon. O. L. McPherson, Minister of Public Works.

J. A. Allan, Geologist, University of Alberta.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

N. C. Pitcher, Mining Engineer, University of Alberta.

R. M. Young, Canmore, Alberta.

Edgar Stansfield, Chief Chemical Engineer, Honorary Secretary.

STAFF.

The following changes in the permanent staff have been made during the year:

Resignations.

W. F. McDonald, Office Assistant, April 30th.

G. Alan Harcourt, Technical Assistant Road Materials Division, April 30th.

Miss Ruth MacLennan, Geological Stenographer, June 21st.

A. D. Wood, Laboratory Assistant, Fuels Division, June 30th.

Nick Melnyk, Assistant Engineer, Road Materials Division, September 30th.

S. Zeavin, Assistant Engineer, Fuels Division, October 8th.

Appointments.

Francis J. Leger, Technical Assistant, Road Materials Division, May 9th.

Miss Alta Jackson, Office Assistant, May 14th.

Jack Reid, Laboratory Assistant, Fuels Division, July 7th.
Mrs. Mary Sandin, Geological Stenographer, September 28th.

The permanent staff on December 31st, 1928, was as follows:
EDGAR STANSFIELD, Chief Chemical Engineer, *Fuels;*
K. A. CLARK, Research Engineer, *Road Materials;*
R. L. RUTHERFORD, Geologist, *Geology;*
W. A. LANG, Assistant Engineer, *Fuels;*
J. W. SUTHERLAND, Assistant Engineer, *Fuels;*
K. C. GILBART, Assistant Engineer, *Fuels;*
HAZEL M. WORTMAN, Accountant and Stenographer;
MARY SANDIN, Geological Stenographer;
JACK REID, Laboratory Assistant, *Fuels;*
ALTA JACKSON, Office Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, members of the Council, are in permanent charge of the Council's research work in Geology and Mining Engineering respectively. Professor A. E. Cameron acts as secretary to the Council and has charge of the office staff.

LABORATORIES AND EQUIPMENT.

Additional laboratory space was provided by extending the second floor completely across the Mining Laboratory. This provided new laboratory quarters for the Road Materials Division.

The principal items of laboratory equipment purchased or constructed during the year are as follows: Gas holder, Calorimeter with stainless steel Scholes bomb, and De Graaf ash fusion apparatus.

FUELS.

Routine work and the continuation of uncompleted investigations during the year resulted in a considerable increase in the data available on the physical and chemical properties of Alberta coals.

The detailed chemical survey of the coals of the province was continued by studies of 23 channel samples and 25 mine samples supplied by the Provincial Mines Branch. The work included proximate and ultimate analyses, and the determination of calorific value, ignition temperature, oxidisability, specific gravity, and maturity of the coal. The results available at that time were published in last year's Annual Report. The new results obtained during the year are not given in this report, but have been reported in detail to the operators of the mines from which samples have been tested. One feature noted is the geographic regularity of the ignition temperature of the coals. Lines of equal ignition temperature can be plotted on a map of the province, and such lines lie roughly parallel to the British Columbia boundary—the further from the mountain divide the lower the ignition temperature. In this respect it closely resembles the moisture and calorific value curves previously published.

No further changes have been made in the procedure adopted last year for the special tests referred to above. The information collected in the chemical survey of Alberta coals has been compiled and studied in relation to the classification of Alberta coals.

Tests on the slacking characteristics were made on 113 coal samples received from the Provincial Mines Branch. These tests were carried out along the lines of the tentative method proposed by the United States Bureau of Mines, as one means of characterising and classifying the coals of the United States of America, but particularly the Western coals. This work was done in co-operation with the U. S. Bureau of Mines, both as a test of the method and of its suitability for comparing the storage qualities of Alberta coals.

No work was done on domestic heaters or residence heating during the year, except that a few special tests were made on a residence near the University.

The study of the coking properties of Alberta bituminous coals was continued. The results have been compiled and show a good range of coking coals in the province.

An effort was made during the year to develop a quantitative test for use in demonstrating the smokeless character of Alberta's domestic coals. No satisfactory test has yet been devised.

The briquetting investigation was continued along the lines of previous years. Considerable more data has been obtained on many of the factors which influence the making of briquettes. In all, 80 batches of briquettes were made—39 with bituminous coal from the Crow's Nest area, 5 with sub-bituminous coal from the Coalspur area, 20 with carbonized lignite and 16 with blended coals. Of these, 20 batches were made with asphalt binder, 4 with asphalt emulsion, 2 with hard coal tar pitch, 2 with sulphite pitch, 23 with crude phosphoric acid and 29 with mixed binders.

E. Stansfield represented the Council at the World Power Conference on Fuels held in London in September and October, and presented a paper "Studies of Post Carboniferous Coals." He also represented the Council at the Second International Conference on Bituminous Coal held in Pittsburgh in November, and presented a paper "Principles of Briquetting Coking and Non-Coking Bituminous Coals," by W. A. Lang and E. Stansfield. Mr. Stansfield also visited coal research institutions, coal processing plants, etc., in England, Scotland, Wales and Germany.

E. Stansfield also served on the Alberta Coal Standards Board, and supplied that body with all the available technical information bearing on their problems.

J. W. Sutherland prepared a thesis "The Classification of Coal"; K. C. Gilbart prepared a thesis "The Coking Properties of Coal"; and S. Zeavin prepared two theses "The Oxidisable Constituents of Coal," and "The Volatile Matter Constituents of Coal with Particular Reference to the Coal and Oil Deposits in Alberta."

J. W. Sutherland also compiled additional data on the coal resources of Alberta for the Honorable Herbert Greenfield, Agent General for Alberta, London, England.

GEOLOGY.

The work of the Geological Survey Division of the Council is carried on in conjunction with the Department of Geology at the University of Alberta, under the direction of Dr. J. A. Allan. The palaeontological material obtained on field surveys is determined by Dr. P. S. Warren, and in return for this co-operation, Dr. R. L. Rutherford assists in teaching in the Department of Geology.

The office was closed during the months of July and August. The correspondence in connection with the Geological Division of the Council was about the same as in the previous year. Information was requested on many minerals and other phases of the natural resources. A large number of requests were for information on the possibilities of obtaining a water supply in various districts, for domestic or town purposes. The number of requests for information on the possible mineral resources in the north was greater than in the previous year.

Two geological reports and one map were prepared by the Council. One of these reports and the map, prepared by Dr. R. L. Rutherford, appears as Report No. 19. The other report, prepared by Dr. Allan, appears as an appendix in Report No. 22. A draftsman was employed for about two months to prepare maps, charts, and other drawings in connection with the geological work.

Two geological parties were in the field during the summer. One party under Dr. Rutherford spent about four months in different parts of the province, but chiefly on the area of the Peace Hills sheet and northwards to Athabaska and Lesser Slave Lake. Mr. L. S. Russell spent about two months in the field in the foothills between Bow river and the International Boundary. This field work was under the direction of Dr. Allan. A short time was spent by Dr. Allan and Dr. Rutherford in investigating geological conditions along the east side of Athabaska valley south of Jasper.

Dr. Allan edited the reports and maps prepared by this division during the year. Daily records of the water flow in Spray river at Banff were looked after and compiled by Dr. Allan. He also compiled additional data on some of the mineral resources of Alberta for the Honorable Herbert Greenfield, Agent General for Alberta, London, England.

An appendix to this report gives the scope of the work carried out by the Geological Survey Division during the year 1928.

ROAD MATERIALS.

The study of road materials during 1928 was confined to laboratory work. Problems arising out of the experimental road construction of the previous year using emulsified bituminous sand bitumen, and of the general study of bituminous sand separation, were investigated.

The road construction experiment of 1927 showed that the use of asphalt emulsions for gravel road treatment involved a problem that is not met in their use for treating macadam roads. The fine sized material in ordinary gravel causes the emulsion to "break"

and prevents a really satisfactory distribution of asphalt over the surfaces of the gravel particles. Since emulsions have many advantages that are bringing them to the fore rapidly for road work, and since their field of application in Alberta would be the treatment of gravel roads, it was considered important to give attention to the "breaking" trouble and to seek a remedy. Progress was made.

It has been realized, as a result of past work, that the process we have developed for separating the bitumen from the bituminous sands depends, to a large extent, on the formation and behaviour of bitumen emulsions. These may be either of the oil-in-water or water-in-oil type, and it is possible for one type to be formed and subsequently invert to the other. A study was made of the types of emulsion formed by the bitumen under a wide range of conditions which included those existing during the operation of separating bituminous sand. The study has cleared up some uncertain points and has provided a better background of understanding of the separation process.

The laboratory separation plant was used for a large number of experimental runs designed to advance the art of separation. This work has lead to important conclusions regarding the cause of variations in the quality of separated bitumen, and has pointed to the way along which improvements in the art may be sought.

The laboratory studies indicated are discussed in more detail in an appendix to this report.

SOIL SURVEY.

A preliminary soil survey was made of the district between Smith and High Prairie under the Natural Resources Act of 1928 and under the general oversight of the Research Council. The work was directed by Dr. F. A. Wyatt, Professor of Soils at the University of Alberta. Mr. J. L. Doughty was in charge of the party, and was assisted by Mr. R. S. Young.

Dr. Wyatt's preliminary report appears in the appendix.

CHEMICAL UTILIZATION OF NATURAL GAS.

An investigation of Alberta natural gas, having for its principal object a study of this gas as a raw product for chemical industries, has been undertaken for the Council by Dr. E. H. Boomer, Assistant Professor of Chemistry at the University of Alberta. The National Research Council of Canada is co-operating with this work and has carried half the cost of the investigation to date.

Dr. Boomer's preliminary report appears in the appendix to this report.

MISCELLANEOUS.

In January Mr. Stansfield read a paper entitled "Coking of Alberta Coals" to the Engineering Institute of Canada at Lethbridge.

In March Dr. Allan and Mr. Stansfield attended the annual meeting of the Canadian Institute of Mining and Metallurgy in Quebec City. Mr. Stansfield also attended committee meetings of

the National Research Council on Mining and Metallurgy and on Coal Classification.

In June Mr. Stansfield attended the Chemists Convention in London, Ontario, and while in the East attended a committee meeting of the National Research Council on Coal Classification.

In July Dr. Allan attended the ceremonies in connection with the commemoration of the opening of the first coal mine in Alberta, at Lethbridge, and spoke on the subject of Coal Resources.

Dr. Clark attended the convention of the Canadian Good Roads Association held in Regina during September and read a paper dealing with the bituminous sands as a source of road material. During October, he spent about a week with members of the Good Roads Board in going over recent road construction in the province and noting features of the work that may lead to investigation by the Research Council.

Dr. Clark contributed a paper on the bituminous sands to the World Power Conference held in London during October. A lecture on the same general subject was given from the University radio broadcasting station.

During the year radio talks on technical subjects were broadcast by Dr. Allan and Dr. Rutherford from the University station, CKUA.

PUBLICATIONS DURING 1928.

Report No. 19, "Geology of the Area Between North Saskatchewan and McLeod Rivers, Alberta," by R. L. Rutherford.

Map. No. 13, accompanying Report No. 19, by R. L. Rutherford.

Report No. 22, Annual Report of Council covering the work done in 1927.

"An Economic Study of Post Carboniferous Coals," by E. Stansfield. Transactions of the Fuel Conference, World Power Conference.

"The Availability of the Alberta Bituminous Sands for Production of Fuel Oil," by K. A. Clark. Transactions of the Fuel Conference, World Power Conference.

"Principles of Briquetting Coking and Non-coking Bituminous Coals," by W. A. Lang and E. Stansfield. Proceedings of Second International Conference on Bituminous Coals.

"Mammal Tracks from the Paskapoo Beds of Alberta," R. L. Rutherford and L. S. Russell. Amer. Jour. Sci., Vol. XV, p. 262, 1928.

"Fossil Zones in the Colorado Shales in Alberta," P. S. Warren and R. L. Rutherford. Amer. Jour. Sci., Vol. XVI, p. 129, 1928.

"Two Interesting Boulders in the Glacial Deposits of Alberta," R. L. Rutherford. Jour. Geol., Vol. XXXVI, p. 558, 1928.

"Anthraxolite from the Northwest Territories of Canada," R. L. Rutherford. Amer. Min., Vol. XIII, p. 516, 1928.

FUELS DIVISION

By E. Stansfield, W. A. Lang, J. W. Sutherland, K. C. Gilbart, and S. Zeavin.

Professor N. C. Pitcher, Chief Mining Engineer, assisted with suggestions and advice with most of the work described.

W. A. Lang continued the briquetting investigation, and assisted with specific gravity and fusion of ash determinations. J. W. Sutherland acted as fuel analyst. K. C. Gilbart continued the investigation of Alberta coking coals and did some other experimental work. S. Zeavin assisted with the analytical work and made determinations of the specific gravity and slacking characteristics of a number of coals. During three months of the year the entire staff was engaged in making a detailed study of the physical and chemical properties of 25 samples of sub-bituminous and domestic coal.

Coals Tested.

Provincial Mine Inspectors submitted 206 coal samples. Of these, 23 channel samples for analysis, 5 channel samples for coking tests, 24 mine samples for specific gravity determinations, and 129 lump samples for weathering tests, were shipped in air-tight containers; while 25 mine samples of about 30 to 40 lbs. each were shipped in wooden boxes. Fourteen other coal samples for analysis were received from various sources. Of the 206 samples, 50 were Kootenay horizon, 60 Belly River horizon and 96 Edmonton horizon coals. Samples were received during the year from 10 mines not previously sampled; and samples from 288 mines have now been analysed.

Sampling and Analysis.

No change has been made during the year in the regular methods of sampling and of proximate analysis. When the object of study is the character of the coal substance, rather than the analysis of a particular sample, the interference due to the presence of mineral impurity is reduced as far as possible by flotation of the finely crushed coal on a solution of suitable specific gravity. Ultimate analyses, maturity of coal determinations, etc., are then made on the low ash sample thus obtained.

In the Eighth Annual Report it was stated that a new apparatus for the determination of carbon and hydrogen had been designed and constructed. Parallel determinations are now being made with this and with the more usual Liebig method. The new method has proved more accurate, quicker and less trouble than the Liebig method.

During the year a new oxygen bomb calorimeter was put into commission for the determination of the calorific value of coal. A

Scholes type bomb constructed of ERA-CR stainless steel was procured from G. Cussons Co., Ltd. This steel was selected for the bomb, as it is not attacked by either dilute sulphuric acid or dilute nitric acid.

The calorimeter itself was designed and assembled in this laboratory. This calorimeter has been found very satisfactory. Three consecutive calibration determinations with standard benzoic acid gave identical results. The steel of the bomb is still as bright after six months service as it was when first made.

CHEMICAL SURVEY OF ALBERTA COALS.

In the eighth Annual Report it was stated that a detailed study of representative Alberta coals was being made. This work was continued during the year. Ultimate analyses and many other tests were made on 38 coals. This brings the total number of ultimate analyses made up to 67; these represent 55 mines in 26 coal areas of the province.

SLACKING CHARACTERISTICS OF COAL.

The tendency to slack on exposure to the weather has been considered characteristic of sub-bituminous and lignitic coals, and is used by the United States Geological Survey in their method of coal classification as the distinguishing property of those coals. The United States Bureau of Mines has recently endeavored to develop a quantitative test for measuring this characteristic.

The test tentatively proposed consists of air drying a 1,000 gram sample of lump coal, of 1 to 2 inch size, for 24 hours in a current of air at 30 to 35 degrees C. These air-dried lumps are then immersed in water for one hour, after which treatment they are again air-dried for 24 hours. The sample so treated is then screened over a wire screen with ¼ inch square openings. The percentage of the coal which passes through the screen is taken as a measure of the slacking tendency of the coal. The action of the water on the sample when it is immersed, and the time during which audible action takes place are to be noted. The procedure of wetting, air-drying, and screening may be repeated on the part of the sample which does not pass the ¼ inch screen. It was suggested that in some cases the cycle might need to be repeated up to eight times with good storage coals.

Many tests were made during the year in order to study the applicability of the test to Alberta coals. In all 113 coals were tested. Bituminous coals lost from 1 to 5% of their weight as fines with the first treatment; sub-bituminous coals 2 to 25% and domestic coals 40 to 100%.

One possible source of error is that some of the lumps may have been weakened or fractured by shot firing. Another uncertainty may arise from the natural friability of the coal causing it to break on the screen. The fines thus produced would be taken to indicate slacking rather than the true cause, friability. It is hoped to correct for these errors by means of blank screening tests.

The audible action referred to above means the crackling sound produced when a piece of dry coal is dropped into water. It has not been found possible to make use of this phenomenon in evaluating the slacking characteristics.

BRIQUETTING.

The briquetting investigation described in the previous Annual Reports was continued intermittently during 1928.

During the year 80 batches of briquettes were made. Classified by coals, 39 were made with bituminous coal from the Crow's Nest Area, 5 with sub-bituminous from the Coalspur Area, 20 with carbonized lignite, and 16 with blended coals. Of these 20 batches were made with asphalt as binder, 4 with asphalt emulsion, 2 with hard coal tar pitch, 2 with sulphite pitch, 23 with crude phosphoric acid and 29 with mixed binders.

The carbonized lignite used in 16 of the above runs was obtained from the plant of the Lignite By-Products Co. of America situated at Drumheller, Alberta. This material was friable and had a large amount of fine dust present. Ten to 12 per cent. of asphalt binder was required with this material in order to make briquettes with satisfactory handling properties.

A sample of briquetting asphalt emulsion was obtained late in the year, but sufficient tests have not been made with it to warrant a decision as to its suitability as a briquette binder.

Physical tests were made on a new sample of asphalt (Imperial Briquette Binder No. 2) received during the year. Briquetting tests with this asphalt indicate that it is a satisfactory binder.

Study of a process developed by T. Nagel, and referred to in the last annual report, was continued during the year. A sample of crude phosphoric acid received from the phosphate plant of the Consolidated Mining and Smelting Company of Canada, Limited, Trail, was used in these tests. Briquettes made in this laboratory using flour and starch pastes, sulphite liquor and various colloidal materials, with additions of phosphoric acid in every case, have always been unsatisfactory. A number of tests were also made using varying amounts of crude phosphoric acid as the only binder. These briquettes were carbonized at temperatures ranging from 200 to 700 degrees C. The quantity of binder required before the briquettes are strong enough to stand handling appeared to be too high for an economic process. The binder and second heat treatment are costly, and it is undesirable to add substances such as phosphoric acid which might cause corrosion. It was observed that bituminous coal briquettes made with phosphoric acid binder did not swell when carbonized or coked.

Very little work was done with colloidal binders. Attempts to soften cellulosic material by fermentation have so far not been entirely successful.

FUSIBILITY OF ASH.

A modification has been tried in the standard method for testing the fusibility of coal ash. The fusibility of an ash, or its clinkering

characteristics, can be demonstrated and studied by heating a series of cones of the ash up to definite temperatures. The cones are then cooled and kept for examination. In each series successive cones are heated to temperatures rising by stages of 25 degrees C (45 degrees F) throughout the range from the first sign of softening up to the temperature at which the ash becomes completely fluid. The well established methods of the American Society for Testing Materials have been followed in the preparation of the ash sample, construction of cone and base, regulation of the atmosphere in the furnace, and control of rate of heating.

In plates I and II several series of heated cones are shown. It can be easily seen from this that different coal ash samples behave in markedly different ways.

Plate No. I.

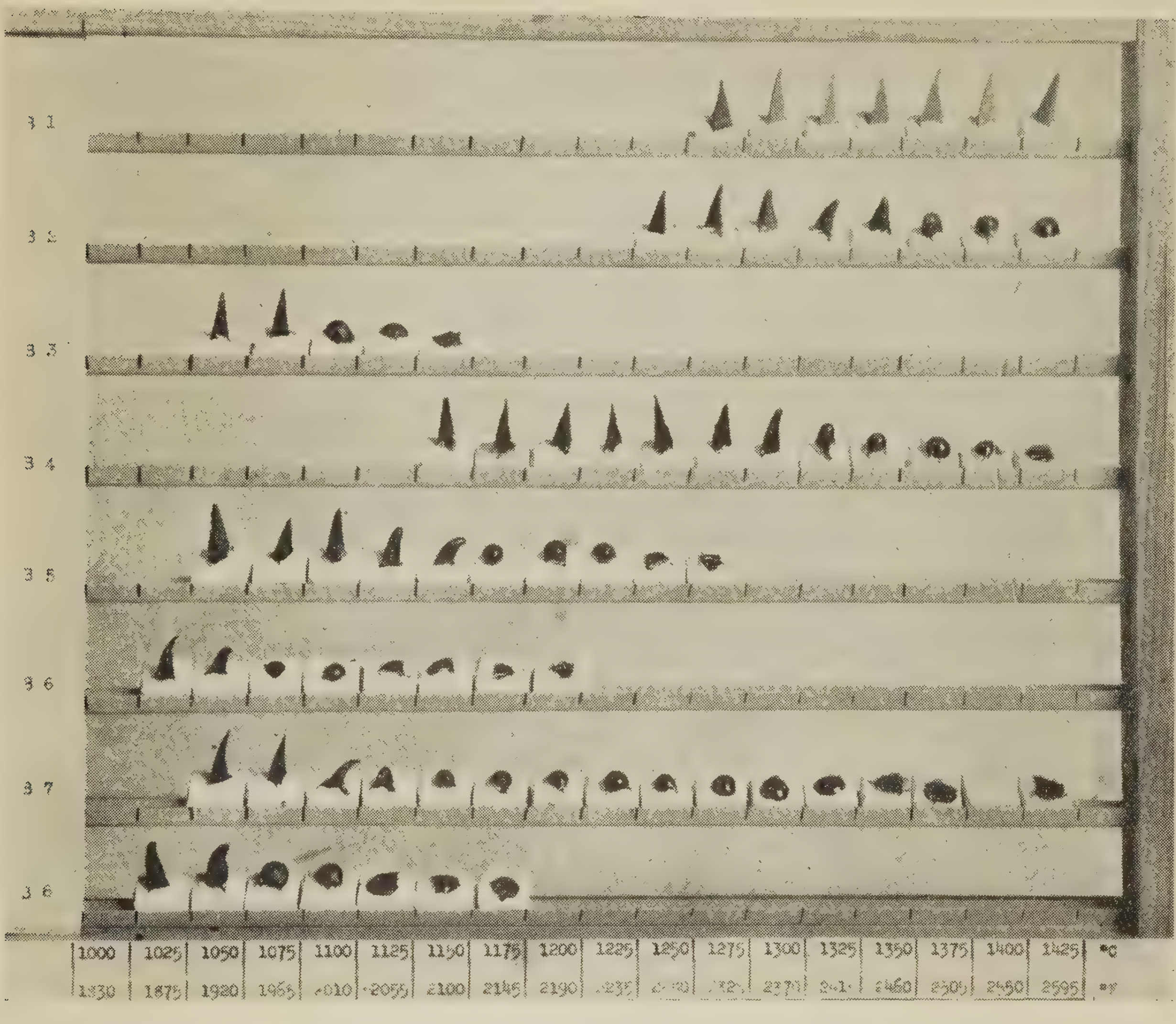

Plate No. II.

To date 59 ash samples have been examined, and some 500 cones have been heated.

The fusibility of the ash of any coal has in recent years been characterised by determining and reporting three separate temperatures; "temperature of initial deformation", "softening temperature" and "fluid temperature." These are determined by heating at a definite rate in a furnace, with a mildly reducing atmosphere, a small cone of the ash made to a specified size and noting the temperature, first when the point of the cone rounds or bends, second when the cone has either fused to a spherical ball or has bent until its point touches the base on which it stands, and third when the cone has spread out over the base in a flat layer. The first of these points is particularly difficult to determine. It is suggested that the newer method described above, with its visible record, will be of greater value than the mere report of three temperatures. Furthermore, the three temperatures can be determined within close limits by examination of the cones if desired.

GEOLOGICAL SURVEY DIVISION

I.—SUMMARY OF INVESTIGATIONS IN 1928.

BY JOHN A. ALLAN.

INTRODUCTION.

With the exception of two months in the summer, the office was open all the year. Compilation of field data and office details on various phases of the geology and the mineral resources of Alberta was carried on throughout the year. One map and two geological reports were prepared and edited for publication. Dr. R. L. Rutherford, geologist, was associated with the writer in all the work of this Division, and in addition gave instruction in the Department of Geology.

Dr. Rutherford prepared Report No. 19, "Geology of the Area Between North Saskatchewan and McLeod Rivers, Alberta," and geological map No. 13, which accompanies the report, from data obtained during parts of the field seasons of 1926 and 1927. He carried on field investigations during the season of 1928, principally in the Peace Hills area south of Edmonton. Other investigations were carried out in several parts of Alberta. Fuller details on the field work are given below.

Fossil material collected in the field or sent in by mail from different parts of Alberta were examined, determined and classified by Dr. P. S. Warren, Associate Professor of Geology at the University of Alberta. These services, so generously given, the writer wishes to acknowledge with thanks. The collection and correct determination of fossils are of the greatest importance to the working out of the distribution of the various geological formations. Close attention is given in the field to the discovery and collection of fossils from the strata being investigated.

Mr. L. S. Russell, who is a graduate of the University of Alberta and who specialized in the study of vertebrate fossils, spent two months in the field in the foothills belt in southern Alberta. Further notes on this field work are given below.

The necessary work in the drafting room was carried out by C. H. Morton for two months, and by S. K. Jaffery and J. S. Neil for short periods.

The correspondence relating to the Division included 29 requests for information on coal and 34 on oil and natural gas resources. Other requests were for information on water supply, clay, bentonite, marl, fossils and rocks, and on various minerals including gold, lead, zinc, salt, gypsum, silica sand, tungsten, pyrite, potash, mica and talc.

Ores, minerals, rocks and fossils received were examined and the parties concerned informed of the results. The samples requiring

chemical analyses were forwarded to Mr. J. A. Kelso, Director of the Industrial Laboratories at the University. Information on various mineral resources and development was supplied at different times during the year to the Hon. Herbert Greenfield, Alberta Government Agent in London, England.

In March the writer attended the annual meeting of the Canadian Institute of Mining and Metallurgy held in Quebec City. When in the east he visited the Topographical Survey of Canada, discussed aerial surveying with Mr. F. H. Peters, Surveyor General, and with Mr. A. Narraway, in charge of field surveys. Arrangements were made to undertake the aerial survey of the northeast corner of Alberta, north of Lake Athabaska and east of Slave river, by the Topographical Surveys. This area includes most of the rocks in the Precambrian shield outcropping in Alberta. This survey was completed during the summer of 1928 and a map is now being compiled in Ottawa from the aerial photographs. The question of an annual aerial program for Alberta, to extend over a few years, was discussed with the Surveyor General.

A set of aerial photographs taken obliquely along Athabaska river between Rapid Joli du Fou in township 81, and Stoney Island in township 91, were purchased from the Topographical Survey of Canada at Ottawa. A key map was also obtained on which has been shown all the areas in Alberta photographed vertically and obliquely by the Topographical Survey of Canada up to the close of 1928.

Publications from the Division in 1928.

Report No. 19, "Geology of the Area Between North Saskatchewan and McLeod Rivers, Alberta," by R. L. Rutherford.

Map No. 13 accompanying Report No. 19, by R. L. Rutherford.

Progress Report on Geological Survey Division, Appendix in Report No. 22, Eighth Annual Report, Scientific and Industrial Research Council, by J. A. Allan.

"Mammal Tracks from the Paskapoo Beds of Alberta," R. L. Rutherford and L. S. Russell, Amer. Jour. Sci., Vol. XV, p. 262, 1928.

"Fossil Zones in the Colorado Shales in Alberta," P. S. Warren and R. L. Rutherford, Amer. Jour. Sci., Vol. XVI, p. 129, 1928.

"Two Interesting Boulders in the Glacial Deposits of Alberta," R. L. Rutherford, Jour. Geol., Vol. XXXVI, p. 558, 1928.

"Anthraxolite from the Northwest Territories of Canada," R. L. Rutherford, Amer. Min., Vol. XIII, p. 516, 1928.

Publications Received in 1928.

Memoirs and maps have been received and are acknowledged, from H.M. Geological Survey, England; reports and bulletins have been received from the Mineral Resources Department, Imperial Institute, London; from New South Wales, Australia; Gold Coast Geological Survey; and from Federal, Provincial and State Geological Surveys, Departments of Mines, several universities and other government and scientific institutions.

FIELD INVESTIGATIONS.

Water Supply.—Several districts in the eastern and southern parts of the province were visited in order to obtain further data on the geology and possible water horizons. Additional information on the possible sources of underground water in certain districts was obtained during the year. Although no definite water supply survey in Alberta has yet been undertaken, the depth of wells and character of the water have always been obtained in districts where field work has been carried out. During the past year requests have come from a few towns and from many farmers for assistance in locating potable water.

In co-operation with the Provincial Analyst, Mr. J. A. Kelso, records are being compiled on the waters sent in for analyses from various parts of Alberta. It is intended that this service shall be greatly extended in 1929, and that ultimately a systematic water survey will be undertaken, especially in those districts where the supply of good water for domestic and industrial purposes is a difficult problem.

Plains Areas.—During the field season 1928, Dr. Rutherford spent considerable time during June, July and August in traversing the area covered by the Peace Hills sheet. The purpose of this work was to continue north the work done in 1924 on the Red Deer and Rosebud sheets, and to connect to the northwest with the work done along the Saskatchewan in 1927. This necessitated an examination of an area lying south of Saskatchewan river and west of Peace Hills sheet.

Special attention was given to the occurrence of coal in the area around Telfordville. Coal outcrops at several places along Strawberry creek. Recently this occurrence has become more important, as the Canadian Pacific Railway are extending their branch line northeastwards from the present terminus at Breton. This new extension of approximately 20 miles in length passes within 4 miles of some of the coal outcrops on Strawberry creek.

In the examination of Peace Hills sheet, attention was given to the occurrence of coal and to possible water horizons. The boundary between the Paskapoo and Edmonton formations, which crosses this area, has been mapped. The thick seams of coal which occur in the Upper Edmonton beds along Red Deer river and along North Saskatchewan river were found to be discontinuous across the Peace Hills sheet. This is believed to be due to the pre-Paskapoo erosion of the Upper Edmonton beds. Fuller details on the results of this field investigation are given below.

During the latter part of September a short time was spent around the east end of Lesser Slave Lake, examining the coal that is being opened up near Sawridge. A visit was also made to the oil well being drilled by the International Oils on the north side of the west end of the lake.

Further examination was made on the stratigraphical succession exposed in the vicinity of Athabaska Landing.

Foothills Belt.—L. S. Russell, who is a graduate in geology from the University of Alberta and who is now continuing a post

graduate course at Princeton University, was engaged for two months to undertake field work in the foothills belt south of Bow river.

His studies in the field were confined largely to the boundary between the Edmonton and Paskapoo formations on the eastern side of the foothills between Bow river and the International Boundary. He made observations on this contact and collected fossils from both formations. Detailed information on the geological character of this contact will be valuable to future investigations on the geology of Alberta south of Peace river.

Water Power Data.—At the request of the Premier, arrangements were made to take daily gauge readings of the water flow in Spray river at Banff. The object of this was to note the variation in flow over a period of months. The daily readings were taken by Mr. N. B. Sanson, at Banff. Photographs of the Spray at critical periods of flow were taken under the direction of Mr. H. J. McLean. These photographs and the compilation of the flow data between May 20th and December 9th, 1928, are on record in this office.

II.—JASPER PARK DISTRICT.

Geological Reports Nos. 6, 9 and 11, published by the Industrial Research Council of Alberta, include a description of the structure and stratigraphy of the foothills belt up to the base of the mountains, between North Saskatchewan river and Athabaska river. Since the geology of the older rock formations in the mountains to the west has not yet been worked out, it was decided to make a preliminary field survey of a part of these mountains in Jasper Park, and to investigate the possible occurrence of phosphate and other minerals that are known to occur in rocks of the same age in other parts of the mountains and on the south shore of Great Slave Lake.

During the past few years formations of Paleozoic age have been penetrated by drilling operations at various places on the plains and foothills of Alberta. These older formations outcrop to a small extent in the northeast corner of the province, on the west side of the Precambrian shield, and are known to occur at depth along the east side of Alberta. The eastern Rocky Mountains are made up largely of these Paleozoic formations. In order to interpret the age or significance of these older rocks penetrated by drilling east of the mountains, it is necessary to have some knowledge of the older formations outcropping within the mountains.

The Rocky Mountains in Jasper Park can be divided into two belts. The older division forms the backbone of the Rocky Mountains and consists largely of Precambrian and Cambrian rocks. The younger division forms the eastern part of the Rocky Mountains and extends to the foothills. The rocks in this eastern division are Paleozoic and Mesozoic in age, chiefly Devonian and Carboniferous, and younger Mesozoic formations belonging to the Triassic, Jurassic and Cretaceous periods. The front of the mountains in Athabaska valley occurs at Brule lake and is defined by an escarpment formed by the massive bedded limestones and shales of the

Devonian and Carboniferous which have been thrust over the Mesozoic strata in the inner foothills.

The eastern or younger division is made up of a number of mountain ranges representing large fault blocks. There is a repetition of the formations in several of these block mountains. The youngest rocks are found on the west of the blocks. Behind the first or more easterly range of mountains, an extensive series of lower Cretaceous strata occurs, including the Kootenay which is coal-bearing. This belt of Kootenay rocks includes important coal seams in what is known as the Pocahontas-Miette coal basin, which occurs three miles west of the south end of Brule lake. Coal was mined for a few years at Pocahontas on the south side of Athabaska river, and also on the north side of the valley close to Miette station on the Canadian National Railway. The Marlboro Cement Company obtains limestone for its cement plant from a point on the railway between Jasper and Henry House station on the Canadian National Railway. In the older part of the Rocky Mountains marble occurs in the Precambrian rocks of such a quality as to be useful as an ornamental stone.

The older and younger divisions of the Rocky Mountains are separated by a fault with a displacement of several thousand feet. This structural break occurs about three miles north of Jasper station and close to the depression which marks the subterranean outlet of Pyramid creek. The shales on this break have been badly crushed and altered. They are black in color and have been mistaken for coal. This major fault continues to the southeast, west of Maligne canyon and cuts across the depression occupied in part by Maligne lake.

Dr. Rutherford and the writer spent about two weeks on a traverse south from Jasper with a pack train. The route followed is shown on the accompanying sketch map (Plate III.) It was up Athabaska valley from Jasper to the forks with Sunwapta river, then up Sunwapta valley to Poboktan creek, up Poboktan and Poligne creeks to Maligne pass, down Maligne river from the pass to the north end of Maligne lake, westward from this lake over Little Shovel and Big Shovel passes, down a very steep trail to Athabaska valley at Buffalo prairie, then down the east side of Athabaska to the bridge at Jasper.

The valley of Athabaska river south of Jasper is broad and rounded by the action of ice. Gravel and sand terraces occur at different levels along the sides of the valley. The highest terrace observed is on the west slope of Signal mountain about 1,000 feet above the valley floor. These terraces indicate different lake levels after the ice melted from the valley. The rocks underlying the valley are chiefly argillites and quartzites of lower Cambrian and Precambrian ages.

From Jasper the broad rounded valley of the Athabaska was followed to Athabaska falls, about 20 miles south of Jasper and 6 miles above the mouth of Whirlpool river. Here the river channel narrows suddenly to a tortuous gorge, 15 feet wide at the narrowest

point and 120 feet deep. This gorge is cut in massive bedded lower Cambrian quartzite (Plates IV and V).

From these falls a side traverse was made to the east to Hardisty creek, which enters the valley in an old channel of the Athabaska. This small stream is blocked by a beaver dam and a lake has been formed at the base of Mt. Kerkeslin. Several beaver were observed at work in the lake. There is a most excellent section of the lower Cambrian rocks exposed in this mountain (Plates V and VI). Many of the beds have a reddish color and some of the shale bands have a deep red color due to the iron content, but these rocks are not rich enough in iron to be called iron ores.

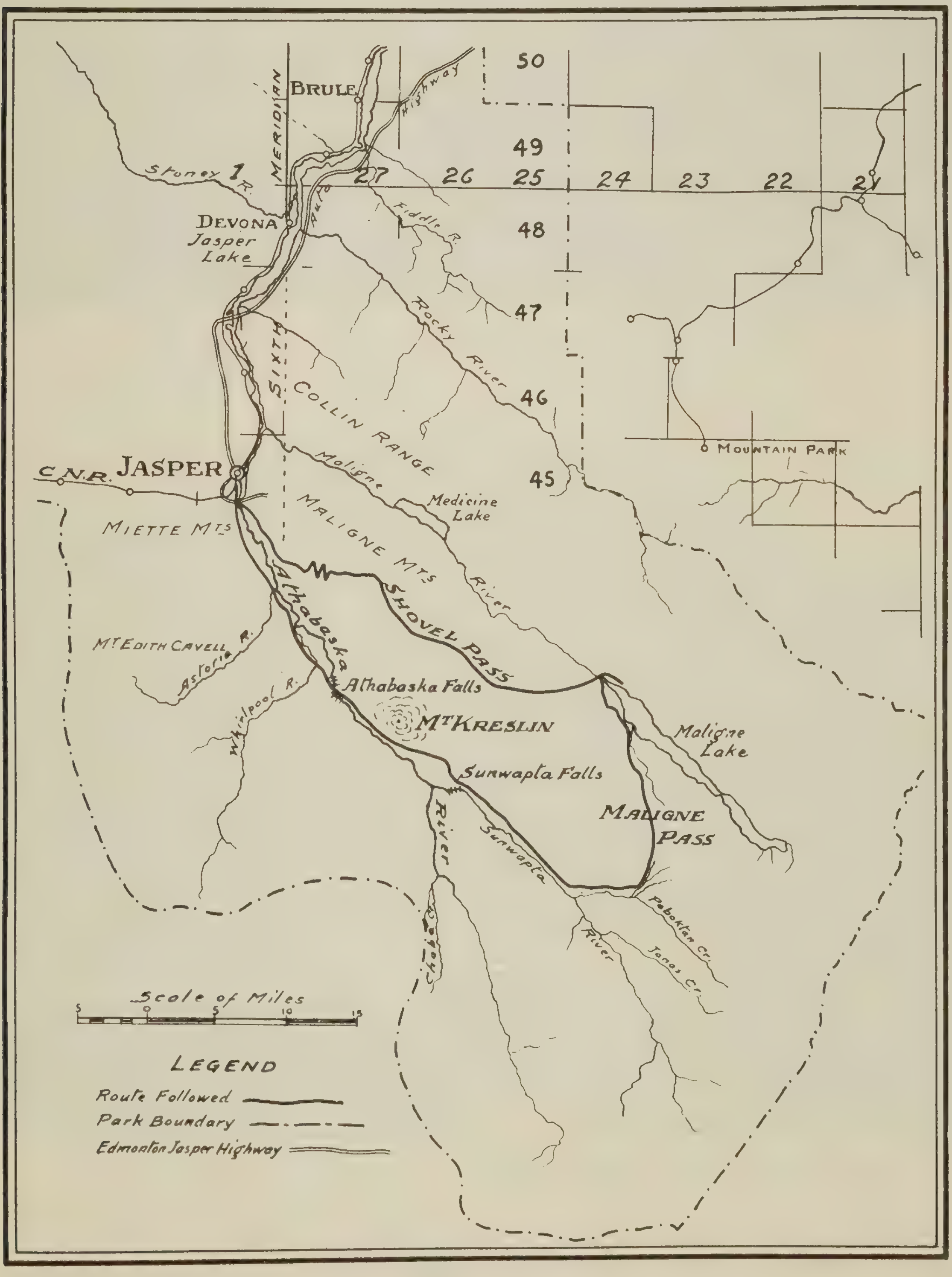

Plate III.

Plate IV.—Athabaska falls, from west side.

Plate V.—Athabaska falls with Mt. Kerkeslin in background.

Mt. Kerkeslin forms the north end of a broad syncline which has an axial dip to the south. The Athabaska falls are formed in beds on the west limb. South from the falls the Athabaska-Sunwapta valley cuts across obliquely onto the east limb of the syncline, which forms the range on the east side of the valley as shown in Plate VIII.

Above Athabaska falls the river channel widens and the trail follows the east side of the river. About 32 miles from Jasper the Athabaska branches and the east fork is the Sunwapta river. Sunwapta falls occur about 6 miles above the forks. There is a "box" canyon with a sharp angle of almost 90 degrees about 30 yards below the main fall which is 75 feet high. The width of the canyon varies from 12 feet at the falls to about 100 feet in the canyon, which is 125 feet deep (Plate VII). The walls of the canyon are perpendicular, overhanging in places, and the rock is vertically jointed, massive limestone, probably middle Cambrian. A rock of this kind would make an excellent building stone if accessible to a market. This rock formation is believed to be of the same age as that exposed in Castle mountain west of Banff, and in Mt. Stephen at Field, in which lead, zinc and some copper and silver have been found, but no mineralization was noted at this point in Athabaska valley. A younger limestone formation was examined about a mile east of Sunwapta falls. These limestone beds are younger than the quartzites that occur at Athabaska falls. The older quartzites outcrop again on the east side of the Sunwapta about five miles above the falls. The dip is to the west.

About 48 miles from Jasper the Sunwapta branches and the east branch is called Poboktan creek, which heads in Mt. Poboktan, 10,700 feet. Brazeau lake, 6,200 feet in elevation, at the head of Brazeau river, lies on the southeast side of Poboktan pass. The trail from the mouth of Poboktan creek to Poligne creek, a distance of 5 miles, is extremely steep, as the underlying rocks are massive, bedded quartzites, possibly lower Cambrian in age, and reddish in color on account of the iron content.

The west branch of Poligne creek was followed up to Maligne pass, with an elevation of about 8,000 feet above sea level. This pass is void of trees and shrubs, but with a luxuriant growth of wild flowers. Maligne pass is on lower Cambrian formations consisting of quartzite, conglomerate with white quartz pebbles, and silicious shales. There appears to be a fault at the mouth of Poligne creek and extending up the valley of Poboktan creek. The rocks on the east side of Maligne pass are middle and upper Cambrian. The strata in the upper part of Replica peak (9,150 feet) belong to the upper Cambrian and are characterized by thin beds of limestones and many colored shales in which red, brown and mauve prevail. The strata are intensely folded and contorted in Replica peak and in other peaks to the east.

From Maligne pass the trail follows down Maligne river, which flows northwest to the base of Mt. Unwin (10,550 feet), then turns north and cuts obliquely through the range west of Maligne lake. This valley is broad and heavily wooded with green spruce and balsam (Plate IX). The river enters the lake about 6 miles

Plate VI.—Mt. Kerkeslin from Athabaska falls. A fine section of lower Cambrian quartzites and shales.

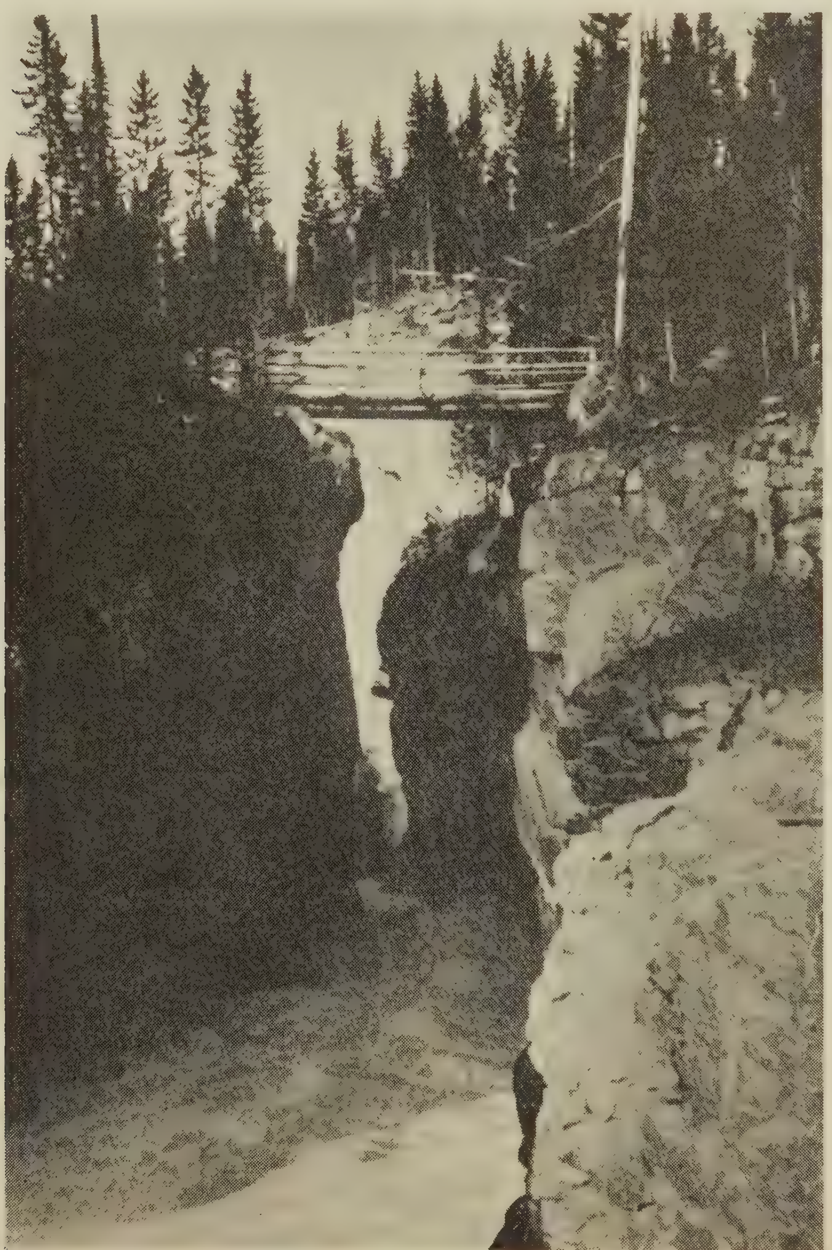

Plate VII.—Gorge below Sunwapta falls, looking down stream.

Plate VIII.—Honeymoon lake, 3 miles north of Sunwapta falls. Westward dipping block mountains of Cambrian quartzites.

from its outlet. The trail follows through very rough country to the outlet of the lake at the north end. There are several large depressions resembling sink holes on the west side of the lake. Some of these are several hundred feet across. These depressions seem to be associated with massive limestones and close to a contact with a shale formation. The limestones are believed to be of upper Paleozoic age. There are several similar large depressions on the east side of the lake. The largest one observed measures 300 feet in diameter and 60 feet deep. It is quite possible that these depressions have been formed by the solution of the porous Paleozoic limestones and the formation of caverns which in some cases have fallen in to form a conical depression. Sink holes and caverns are known to occur in rocks of the same age at many places north of the International Boundary, at the Crow's Nest pass, at Banff, north of the Bow, and at the Saskatchewan. There are also large depressions of similar character along the south side of Athabaska valley west of Maligne canyon. It is quite possible that caves of considerable size may yet be found in the rocks associated with and underlying these depressions.

A traverse was made up the side of the range on the east side of Maligne lake. The lower slopes are extremely irregular and broken, and indications of intense faulting were observed. On this slope there are limestone blocks many feet in diameter. One large monolith of light grey limestone measures 25 by 30 feet and is 60 feet high. There are also numerous depressions on this slope.

Above timber line toward the top of the range there is an excellent section exposed. Only the upper part of this section was

Plate IX.—Looking down Maligne river valley from one-half mile north of Maligne pass.

examined, where the phosphate horizon was believed to occur. The section examined consisted of a massive limestone formation corresponding to the Rundle formation (upper Banff limestone) of lower Carboniferous age. This formation is overlain by about 350 feet of quartzite, which is believed to correspond to the Rocky Mountain quartzite at Banff and in Crow's Nest Pass, and which is overlain by a series of several hundred feet of shale which corresponds to the Spray River formation (upper Banff shale) of lower Triassic age. A phosphate horizon in Alberta occurs near the contact of the quartzite and shale formations. The strata at this horizon were examined for phosphate. Some of the shale beds are distinctly phosphatic, but no high grade beds were observed in the short time available for the examination. On account of the importance of phosphate, more extended investigations should be made in the mountains in central Alberta for this mineral.

Maligne lake is 15 to 18 miles long and averages about one mile in width. It has an elevation of 5,460 feet above sea level, and is walled in at the upper end (south) by bold rock-faced mountains with patches of snow and glaciers. This is one of the most magnificent lakes in the Rocky Mountains. The outlet of the lake is a narrow gorge in thin-bedded limestones and shales of Paleozoic age. An older outlet occurs about a mile to the east of the present one. There is a small but artistic chalet constructed in keeping with the surroundings, at the north end of the lake. A motor boat plies on the lake for the convenience of tourists. One trail extends down

the valley of Maligne river to Medicine lake and Maligne canyon. The other trail has been constructed to the west over Shovel pass to the Athabaska valley.

From the lake the Shovel pass trail was traversed. The surface is extremely irregular for the first five miles. There are numerous depressions similar to those to the south on the west side of the lake. In some of these are small, emerald colored lakes.

Shovel pass lies about 2,000 feet above Maligne lake and is so called because of its open, scoop-like appearance. There are really two divides to this pass, known as the "Little Shovel" and the "Big Shovel." Big Shovel is about 150 feet higher than Little Shovel, and the distance between them is about 8 miles (Plate X).

The rock underlying the pass is mostly shale, which weathers into smooth, regular slopes, very poorly drained and extremely soft throughout most of the season. There are no trees and very little grass on the pass, the vegetation consisting chiefly of wild flowers. These shales are believed to belong to the Spray River formation (upper Banff shale). Well preserved fossil remains of fish are said to occur in these shales. Only a short time was spent on the examination of them on Shovel pass. Although no fossil fish were found on Shovel pass, fragments of fossilized fish remains were found in shales of the same age where they outcrop on the east side of Athabaska river near the highway bridge north of Henry House station.

At the western side of the pass the descent is most precipitous, over the massive lower Cambrian quartzites. There is a major fault between the shales and quartzite formations at the west side of the pass, and this is the southern continuation of the major structural break between the old and new divisions of the Rocky Mountains, which was described earlier in this report as occurring about three miles north of Jasper station.

This trail from Shovel pass to Athabaska is usually traversed from east to west because the descent from the pass to Athabaska is so steep that it is difficult to take pack and saddle horses from west to east. The trail reaches Athabaska valley close to Buffalo prairie, and follows the east side of the valley to the traffic bridge at Jasper. The surface on the east side of the river is irregular, with numerous ridges and depressions. Oldfort Point is on the northern end of one of these quartzite and slate ridges, overlooking Athabaska valley and Jasper.

A trip was also made up to the base of Mt. Edith Cavell on the recently constructed automobile highway. The rocks in the base of this magnificent mountain are largely quartzites, probably of lower Cambrian age. These rocks disintegrate to a fine, rusty sand. There may be some Precambrian rocks between this mountain and Athabaska river, but none were recognized. There is marble of excellent quality in the Precambrian rocks exposed at Grant brook near Yellowhead pass, and it was thought that these might extend to Athabaska valley south of Jasper, but this rock was not observed.

The writer wishes to acknowledge with thanks the kindness shown by the Superintendent of Jasper Park, Mr. R. Knight, and

Plate X.—Summit of Big Shovel pass, looking west and north.

his staff. Permission was given to use the various cabins and telephone service along the route followed. Mr. Langford, Supervising Warden, supplied maps and information which were much appreciated.

III.—PRELIMINARY NOTES ON THE GEOLOGY OF THE PEACE HILLS AREA.

By R. L. Rutherford.

Introduction.—During 1924 the Geological Survey Division of the Scientific and Industrial Research Council made a survey of the area covered by the Rosebud (No. 165) and the Red Deer (No. 215) sectional sheets. These have been published as geological maps Nos. 8 and 9, accompanying Report No. 13. In 1926 and 1927 the writer examined the area along North Saskatchewan river. The results of this work are given in geological Report No. 19. In 1928 the writer examined the intervening area.

This area, as shown in Plate XI, lies mostly within the Peace Hills sectional sheet (No. 265), which includes townships 41 to 48, ranges 15 to 28, west of the 4th meridian. In order to connect the work of 1924 with that of 1927, it was necessary to examine, in addition, some districts to the north and west, namely, the northeast corner of the Brazeau sheet (No. 264) and the southeast corner of the St. Anne sheet (No. 314) covering an area south of Saskatchewan river.

General Geology.—The area referred to is underlain by the Edmonton (upper Cretaceous) and Paskapoo (lower Tertiary) formations. The boundary between these formations crosses the

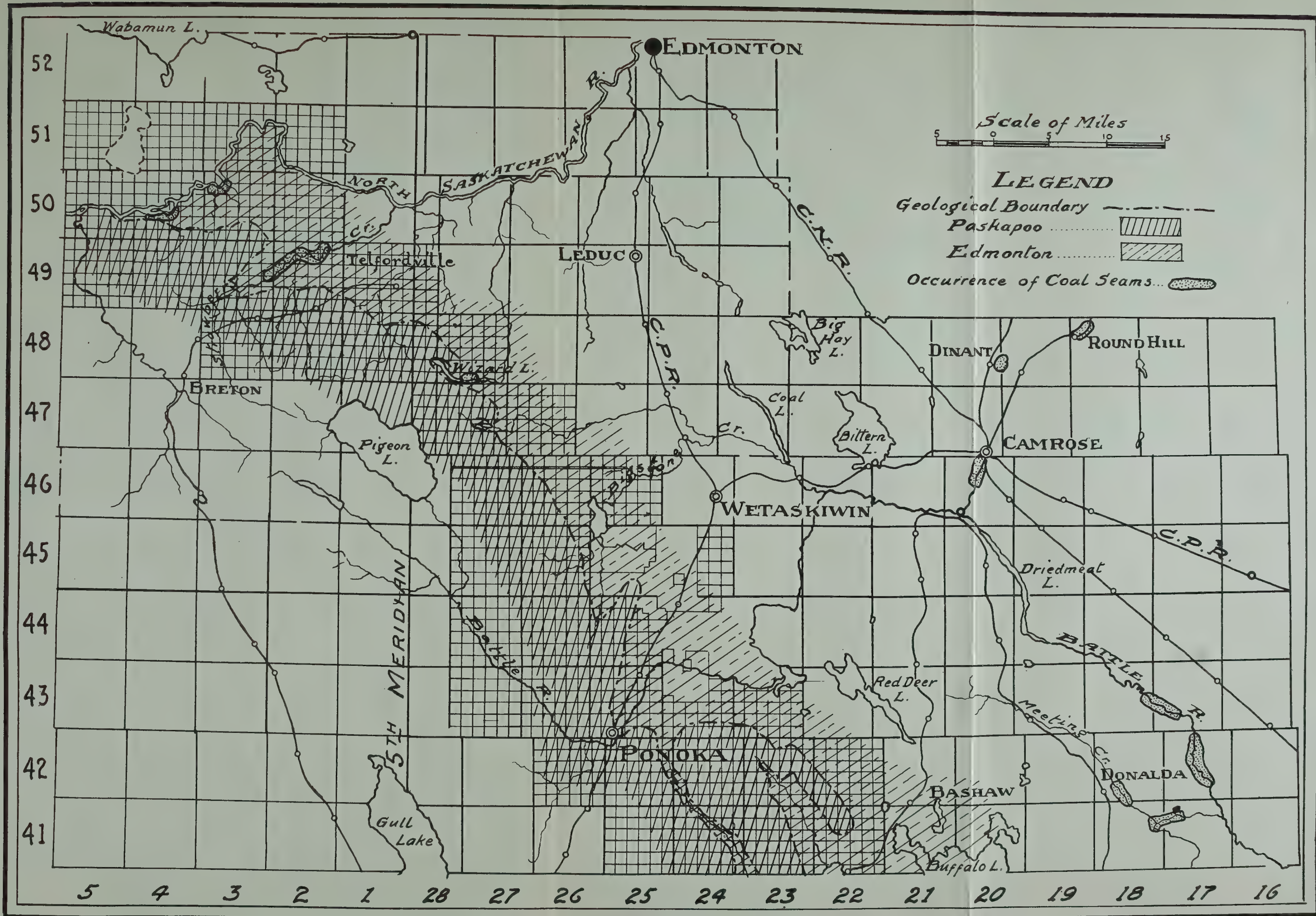

PLATE XI.—Geological map of Edmonton to Ponoka district showing position of Edmonton-Paskapoo boundary.

west half of the Peace Hills sheet in a northwesterly direction, as shown in Plate XI. The stratigraphical relation of the Edmonton and Paskapoo formations along the Saskatchewan has been discussed in detail in Report No. 19, and along the Red Deer in Report No. 13. At these localities the Paskapoo has been found to rest disconformably upon the Edmonton formation. Similar relations were found to exist in the intervening area. This feature is important when the areal distribution of coal seams is considered.

The field information obtained with respect to areal distribution of the Paskapoo and Edmonton formations necessitates a change in the position of the boundary between these formations. Previous maps all show the Paskapoo formation extending further east than the data obtained by the writer would indicate. These maps show it to underly Wetaskiwin and areas to the east of Hobbema. The writer has placed the eastern boundary 10 to 15 miles further west in this district, while Wetaskiwin and Hobbema districts are believed to be underlain almost entirely by Edmonton beds. In fact, the Edmonton beds are thought to extend up the Battle valley almost to the town of Ponoka. This is considerably different from earlier interpretations, which indicated that approximately 400 feet of Paskapoo beds occurred at Ponoka and Wetaskiwin.[1]

Coal.—The upper part of the Edmonton formation carries thick coal seams which are exposed on both the Red Deer and Saskatchewan rivers. If there had been no pre-Paskapoo erosion of the Edmonton, these thick seams would likely have extended across the entire distance between the Red Deer and Saskatchewan rivers. This erosion, however, in removing the upper part of the Edmonton, also removed the coal from the greater part of the area under consideration. Consequently, the occurrence of coal in the upper Edmonton is patchy and is found in places where pre-Paskapoo erosion was relatively less. There are no known occurrences of thick seams in the upper part of the Edmonton formation in the greater part of the Peace Hills sheet. Some thin seams occur, at or near the surface, near Hobbema on the Indian Reserve. A thin seam has also been prospected in Upper Edmonton beds east of Ponoka in section 35, township 42, range 23. A seam averaging 5 to 7 feet in thickness outcrops in L.S. 12, section 3, township 48, range 27, on the north shore of Wizard lake (Conjuring lake). This seam is mined here during the winter season. This is the only definitely known occurrence of a thick seam in the upper Edmonton in the area covered by the Peace Hills sheet. A seam 15 feet thick is reported to have been reached in a 30-foot well near Hobbema some years ago. The writer was unable to obtain verification of this, and is of the opinion that such a seam does not occur, at least over any appreciable area, for if such were the case it would undoubtedly have been encountered several times in the numerous water wells that have been put down in recent years.

Seams of appreciable thickness occur in the upper Edmonton beds in outcrops northwest of the Peace Hills sheet. These occurrences are along Strawberry creek in township 49, ranges 2 and 3, W. 5th, in the vicinity of Telfordville post office. Two seams occur

[1]Geol. Surv. Can., Mem. 116, 1919, pp. 71-73.

here and are exposed at several places along the creek valley. The lower seam, which has an average thickness of 4 to 5 feet, is best exposed in section 27, township 49, range 2, where outcrop coal is taken during the winter by local inhabitants. The upper seam is best exposed in the S.E. ¼ of section 32, township 49, range 2. It averages over 5 feet and in places is 8 feet thick.

These coal seams could be used at present for small local demands, and may possibly be developed in the near future to supply the demand along the railway to the southwest. At present Breton station is the terminus of the railway which runs northwest from Lacombe, but a 20-mile extension to the north and east from Breton is under construction (Plate XI). This extension cuts across the southeast corner of township 49, range 2, and in places is within 3 to 4 miles from the coal outcrops on Strawberry creek. These seams could be reached at points along the new railway by sinking shafts. The depth to the coal at such places would be about 250 feet.

These seams exposed on Strawberry creek probably represent the thick upper seam occurring on Saskatchewan river, where it is in places 25 feet thick. It appears that this thick seam has either thinned or split into several in a southeasterly direction. It is also believed that the seam exposed on the north side of Wizard lake is at approximately the same horizon.

Rock outcrops are comparatively scarce in the district, and it is difficult to arrive at definite conclusions respecting the lateral continuity of these seams, away from the present outcrops. With agricultural development and settlement stimulated by new railway construction, it is probable that lateral continuation of the coal may be penetrated in domestic water wells near Thorsby.

In addition to the coal in the upper Edmonton, there are also seams of mineable thickness occurring in lower Edmonton beds in the Peace Hills sheet area. The thickest of these occur along Battle river in townships 41 and 42, and to the north in the vicinity of Camrose, Dinant and Round Hill. Those in the southern part are on the whole thicker and more continuous than those to the north, but are further removed from railway transportation. Consequently they have not been mined to as great an extent as in the vicinity of Dinant and Round Hill.

Further field work is necessary before these seams can be definitely correlated with those occurring in the Edmonton formation along Red Deer river.

Water Supply.—The supply of water is becoming increasingly important, especially in the eastern part of the area at and around the towns underlain by the Edmonton formation, such as Wetaskiwin and Camrose. The Edmonton formation is largely composed of compact clays and shales which are impervious to water migration. Most of the seasonal precipitation remains at or near the surface in lakes or ponds, and with the development of the districts, many of these surface reservoirs have been drained by reclamation or highway ditches. This permits a rapid run-off of much of the water supply. This feature is especially noticeable in the eastern

part of the area where a network of drainage ditches crosses from north to south.

The general absence of coarse clastics in the Edmonton formation and the impervious nature of most of the beds, does not favor the possibility of finding good water horizons at comparatively shallow depths.

The domestic water supply does not present as difficult a problem in the western part of the area which is underlain by Paskapoo beds. The lowest beds of this formation are massive, porous sandstones, forming ideal water reservoirs, and at many places along the eastern boundary of the Paskapoo where such beds form a capping of the upper Edmonton, numerous springs are encountered.

There is also a sandstone horizon in the upper part of the Edmonton, which may serve as a shallow water horizon in places. It is exposed along Bigstone creek where the Calgary-Edmonton highway crosses, and along the upper part of the valley sides of Coal lake. This sandy phase may grade laterally into shales, but in the district where it is known to occur it probably forms a good water horizon at least for small wells. The eastern boundary of this sandstone phase in the Edmonton lies west of Bittern lake.

Sand and Gravel.—This area was subjected to glaciation, and although deposits resulting therefrom are widespread, they are on the whole thin and patchy, and in many cases are mixed with material derived from the underlying formation. Post-glacial erosion and silting has probably covered a considerable amount of morainal material left by the retreating ice.

The most important deposits of gravel, believed to be due to glacial action at least in part, are those occurring between New Norway and Ferintosh. Boulders and gravel occur at several places along the railway and highway between these two towns. The gravels are cleaner and more concentrated at Ferintosh, where they are used for commercial purposes.

There are apparently large quantities of till in many places surrounding the numerous small bodies of water lying east of Bashaw and north of Buffalo lake. Prospecting in this general area may reveal the presence of gravel deposits suitable in size and quality for industrial uses, but in most of the surface exposures seen in a general traverse there is a large percentage of clay and silt in these deposits.

Sands of glacial or post-glacial lake deposition are prevalent at several places in a belt extending south from Millet to Morningside. Such sands are abundant just north of Wetaskiwin, forming the Peace Hills, and in similar hills east of Millet. They are prevalent around Bearhills lake west of Wetaskiwin, east of Ponoka along the upper part of the Battle valley, and along the bottom of a broad depression at Morningside.

The writer is of the opinion that these were largely derived from erosion of the basal beds of the Paskapoo formation, since these beds are in many places massive sandstones, and since the distribution of the present sand deposits is in most places not far removed from the eastern boundary of the Paskapoo formation.

These sands are on the whole too argillaceous and fine grained to be used for industrial purposes.

Coarser glacial deposits are more prevalent in the western part of the area. These are represented mostly by boulders of gneiss and schist, which are sometimes as much as 3 feet in diameter. One of the largest areas of boulders is situated in the western part of township 47, range 26, and the eastern part of range 27, in the general vicinity of Long and Wizard lakes. Such areas are unsuitable for agricultural purposes.

Natural Gas.—Small quantities of gas have been encountered in drilling water wells at several places within this area, and some deeper tests have been made with a view to obtaining a larger supply of gas.

A deep test was made a number of years ago at Ponoka in an attempt to secure gas for the mental hospital. This well is recorded to have reached a depth of 2,257 feet.[1] Gas was struck at several horizons, ranging in depth from 853 to 2,300 feet. The strongest flows occurred in the lower horizons, but were insufficient to supply the needs of the institution. Several comparatively deep wells have been drilled at Wetaskiwin, the later ones being chiefly in search of water. The gas obtained from some of these wells is used for generating power in Wetaskiwin.

Gas was also encountered in a test well drilled at Camrose a number of years ago, but not in sufficient quantity to be of value.

The gas horizons penetrated by wells at Ponoka, Wetaskiwin and Camrose are all in Edmonton or older beds. The upper horizons are in Edmonton and cannot be expected to be prolific producers at any time or place, owing to the nature of the formation as outlined above. The gas from the lower horizons in these wells is very probably from Belly River beds, and there is a greater likelihood of these horizons being more productive, in some districts, although to date, where they have been tested, they have not been very productive.

Some shallow wells produce gas which has been used by individual householders for domestic purposes. Mr. E. F. Bresee, residing in section 33, township 43, range 27, about 14 miles northwest of Ponoka, has been using gas for heating purposes from water wells 180 to 190 feet deep, for the past 8 years. The life of a gas well here is 2 to 3 years until the well becomes flooded with water, and new wells have to be drilled to obtain gas. The writer is of the opinion that this gas is coming from basal Paskapoo beds. A small quantity of gas was struck recently at the town of Meeting Creek while drilling for water. This is also used on a small scale for domestic purposes.

In general, it does not seem likely that any large quantity of gas will be struck in the upper beds in this area by any subsequent drilling to depths of 2,000 to 2,500 feet. That which does occur at horizons above 2,500 feet has so far proven to be of small quantity, apparently from pockets or lenses of more porous beds. The prevalence of coal in the Edmonton beds and also its presence, although

[1]Geol. Surv. Can., Mem. 116, p. 71.

in lesser amounts, in the Belly River below, would suggest that most of the gas is derived from the metamorphism of coal.

One test for oil has been made in this area. A well was drilled in section 14, township 47, range 27, near Long lake, about 18 miles west of Millet. This well is said to have reached a depth of about 1,100 feet. It was located on surface evidence in the form of bituminous sand. This bituminous sand has since been proven to be a glacial boulder from the northern Alberta deposits at McMurray.

IV.—ATHABASKA AND LESSER SLAVE LAKE DISTRICTS.

By R. L. RUTHERFORD.

During the latter part of September a reconnaissance trip was made from Athabaska to Lesser Slave Lake. The trip as far as Sawridge was made by automobile over the Peace River highway, which was under construction in certain parts. This highway extends north from Edmonton to Athabaska, then northwestwards to Smith. Agricultural settlements extend along the route for about 25 miles from Athabaska, but from this point to Smith there are very few settlers. At Smith the Athabaska is crossed by ferry and the highway follows roughly along the northeast side of Lesser Slave river to the east end of Lesser Slave lake.

A short time was spent at Athabaska in locating the position of the contact of the sandstones with the underlying shale series. This contact is well exposed in the valley of Muskeg creek about 4 miles southwest of Athabaska. The precise location is L.S. 3, section 1, township 66, range 22. North from the contact black marine shales are exposed in several cut banks along the valley of Muskeg creek. The contact is approximately 250 feet above the river at Athabaska. These marine shales are not very fossiliferous along Muskeg creek. These beds belong to the La Biche shales which are believed to be Pierre in age.[1] The strata overlying these shales are composed chiefly of sandstones and arenaceous shales of fresh water deposition, the lowest beds being massive sandstones which are well exposed along Muskeg creek. These are in all probability the equivalent in age to the Belly River beds exposed in eastern Alberta, and are not of Edmonton age.[2] The shales are believed to be represented in an eroded outcrop where the highway crosses the Tawatinaw river about one-half mile north of Meanook station. The basal members of the overlying sandstone are believed to occur in the valley sides near Meanook and about the level of the railway station. Consequently, the coal which was mined to a small extent at Rochester to the south, and the thin seams occurring near Perryvale, are within the lower part of this fresh water series of beds, and are of Belly River age.

There are no rock exposures along the overland route from Athabaska to Smith and Lesser Slave lake. Unconsolidated sand is very prevalent on the surface at Smith. The Lesser Slave river was examined at many places between Smith and the lake, but no outcrops were observed.

1Geol. Surv. Can., Mem. 108, 1919, p. 74.
2 idem.

The geology of the Swan hills to the south of Lesser Slave lake has been studied by Allan,[1] who found the upper formations here to be of late Cretaceous and early Tertiary ages. The lower part of the succession is poorly exposed around the lake. Thin coal seams occurring in the lower slopes of the hills have been prospected at a number of places along the south side of the lake.

During the summer of 1928 the Slave Lake Coal Company were extending development of a small mine situated about 5 miles south of Sawridge. A good road has been constructed to the mine, and the output is largely consumed at Slave Lake and other points along the E.D. and B.C. railway.

The seam is about 4 feet thick with a clay parting near the centre. This parting averages 8 to 14 inches in thickness. The location of the mine entry is L.S. 6, section 23, township 72, range 6, and is about 250 feet above the level of the lake. The coal is here underlain by at least 190 to 200 feet of beds of fresh water deposition, which belong to the formation overlying the La Biche shales. Allan assigned the name *Sawridge* to this formation. This exposure is about 50 feet above the lake.

Some thin coal seams are exposed in the lowest outcrop of consolidated beds on Driftpile river in the S.E. ¼ section 2, township 73, range 12. This horizon corresponds approximately to that carrying the coal south of Sawridge, since the beds are nearly flat-lying in this general district.

The International Oils have been carrying on drilling tests on the northeast side of Lesser Slave Lake. Number 1 well, situated on the lake shore in the S.E. ¼ section 30, township 74, range 6, was drilled to a depth of 2,840 feet. The Paleozoic formations were encountered at a depth of approximately 2,100 feet. Number 1 well did not prove productive and the equipment was moved northeast to a point near the mouth of Marten creek, where No. 2 well was started in the N.E. ¼ section 7, township 75, range 6. This well was being drilled during our visit in September, 1928, and has been drilled to a depth of 3,105 feet without satisfactory results. The company at present are planning on drilling a third test well in this general district.

There has always been some doubt as to whether Lesser Slave lake is underlain by the La Biche shales or younger beds. Exposures of rock around the lake are few and definite evidence is difficult to obtain. The International Oils company state that both No. 1 and No. 2 wells penetrated shales at the surface, and one weathered exposure a few feet above lake level near Widewater looks to the writer much like decomposed La Biche shales.

From data thus far obtained, it is concluded that the contact of the La Biche shales and the overlying series occurs only a short distance above the level of the lake, at least along the south shore.

The coal south of Sawridge and that in the lowest exposure on the Driftpile, occur in the lower 300 feet of beds overlying the marine La Biche shales, and can thus be correlated in a broad way with the coal occurring at Rochester, where it occupies approximately the same stratigraphical position.

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[1] Allan, J. A., Geol. Surv. Can., Summ. Rept., 1918, Pt. C., p. 7.

ROAD MATERIALS DIVISION

By K. A. Clark.

Asphalt Emulsion and Gravel Road Treatment.

An account of an experimental road construction project was given in the Eighth Annual Report. The principal feature of this project was testing the suitability of an emulsion of the bitumen from the bituminous sands for gravel road treatment. The results of the experiment indicated possibilities of importance from the standpoint both of providing a useful and practical application for bituminous sand products and of improving gravel road construction methods. But the experiment also revealed a problem which must be solved before the possibilities indicated can be fully realized.

The gravel and emulsion were mixed together in a concrete mixer. The result anticipated was that the fluid emulsion would spread through the gravel so that when the water evaporated from the emulsion each particle would be coated with bitumen. What actually happened was that the emulsion "broke" in the course of the mixing, liberating water which prevented the larger sand and gravel pebbles from becoming covered with bitumen. Nevertheless the bitumen was well distributed through the gravel mass and gave it good bonding qualities, although there was not uniform spreading over surfaces. The use of asphalt emulsions in the construction of broken stone roads is well established, and there is no difficulty in spreading the emulsion over the surfaces of broken stone. Apparently the case is different with gravel. Since the gravel road is the type being constructed in Alberta, a solution of the problem of mixing asphalt emulsion satisfactorily with gravel must be found before emulsions can become an important road material in this province. Also, a solution of this problem must be found before manufacture of emulsion from the bituminous sands can have full significance from the standpoint of bituminous sand development.

The principal difference between a crushed rock aggregate and gravel that one would suspect to be connected with the behaviour of admixed emulsion is that the crushed rock is comparatively free from fines whereas the gravel contains particles ranging in size down to dust. This suspicion is strengthened by a review of the advertising literature circulated by manufacturers of asphalt emulsions for road work. The aggregates recommended contain a minimum of small sized material, and the desirability of having the stone clean and free from dust is stressed. Apparently finely sized material leads to trouble with asphalt emulsions.

This idea was investigated in the laboratory. Some gravel was divided into the portions of it that were retained on and passed through a 48 mesh Tyler sieve. Each size was well washed to remove very fine material. A quantity of each portion was then

stirred with an excess of emulsion containing approximately 40% bitumen by weight. The larger sized material caused no breaking of the emulsion during a short period of stirring whereas the finer material promptly caused breaking. Some sandstone, limestone, and lignite coal were crushed separately to pass through a 48 mesh sieve and then washed free from extremely fine material. The fine sandstone did not cause the emulsion to break, but the fine limestone and coal did. As would be expected, silt, clay, and soils caused breaking of the emulsion.

A supply of gravel was next separated into material passing the 4 mesh and retained on the 8 mesh Tyler sieves, passing 8 mesh and retained on 14 mesh, passing 14 mesh and retained on 28 mesh, passing 28 mesh and retained on 48 mesh sieves. Each size of material was washed free from silt and clayey material. Sufficient emulsion (containing approximately 50% bitumen) was mixed into samples of each sized material to give the mixture a bitumen content of 3% by weight. It was found that the emulsion mixed without breaking with the three largest sizes and coated each particle uniformly. With the smallest sized material, however, the emulsion broke before it could be mixed. The result was a speckled looking mixture. The separated bitumen enmeshed and stuck together agglomerations of particles while the liberated water wetted other sand particles and prevented bitumen from adhering to their surfaces.

Several interesting observations were made while studying the behaviour of emulsion with gravel. It was found that if a sample of gravel were mixed with from ½% to 1½% of its weight of kerosene, emulsion could then be mixed into it without breaking and a satisfactory distribution of bitumen resulted. Also if the emulsion and gravel were heated to about 150°F. a satisfactory mixture could be made. In the case of the heated materials, the emulsion probably broke or inverted to the water-in-oil form of emulsion, but liberated no water at the elevated temperature in doing so. Since there was no water present to wet sand surfaces and prevent adherence of bitumen, the water-in-oil emulsion spread over all surfaces as a result of the mixing.*

Since mineral particles of smaller size than 50 mesh causes an emulsion to break, one would expect that it would be impossible to emulsify the bitumen in bituminous sand and separate it from the sand in this way as an oil-in-water emulsion. The sand constituent of bituminous sand is mostly all finer than 50 mesh. However, it was found possible to do this. Using oleic acid and silicate of soda as emulsifying agents, the bitumen could be emulsified in the presence of the sand. Yet this emulsion would break when mixed with the fines from gravel.

It is characteristic of asphalt emulsions that when mixed with mineral matter they break. It is this property that makes them a useful road material, for otherwise the emulsion could be all washed out of a road bed by rain following construction. However, with a mineral aggregate such as crushed rock, free from dust and fines,

*In support of this theory it was noted that if the emulsion were considerably diluted, or if the gravel were well wetted with water, the breaking trouble appeared in spite of the materials being heated.

the period between the introduction of the emulsion and its breaking is amply long to allow of thorough mixing and coating of all surfaces. As the sizing of the mineral matter is reduced, it would appear that the time before breaking is also reduced. In the case of run of pit gravel, this time is so short that there is no opportunity to mix by stirring before the emulsion is broken.

The laboratory work did not produce a remedy for the difficulty of mixing emulsion into gravel, but it did lead to some clear ideas about where a solution could be found. In the first place, the fact that it is possible to emulsify bitumen in the presence of very fine sand indicated that it is also possible to make an emulsion that will not break, at least for some time, when mixed with fine material. The factors involved are probably very subtle ones, and a large amount of research may be required to gain a thorough understanding of them. It is of interest, in this connection, to note that the Bitumuls Corporation of San Francisco is now advertising an emulsion for use for surface treatment of gravel roads which has a retarded breakdown time.

A more hopeful way of getting a satisfactory practical solution of the trouble would appear to be to adopt a method of mixing the gravel and emulsion which does not involve a "time of mixing." It is obvious that pug mills, concrete mixers and the like, require time to mix together the ingredients placed in them and are consequently unsuited for mixing gravel and asphalt emulsion. There would appear to be hope of avoiding the whole trouble by spraying the emulsion onto a falling cascade of gravel. The emulsion sprays without breaking. Falling gravel would be separated into its individual particles fairly completely and in falling through a space into which emulsion spray was directed, the particle surfaces should become coated with emulsion and the meeting of gravel particle and emulsion would be instantaneous. Equipment for accomplishing this operation should have a satisfactory through put, allow of fairly close control of proportions in which gravel and emulsion are mixed and fit in readily with the standard facilities employed for excavating and loading gravel.

Emulsion Formation During Bituminous Sand Separation Operations.

There are a number of features about our hot water process* for separating the bitumen which make it appear that the formation and properties of bitumen emulsions play an important role.

1. The first operation of the separation process is the heating and mixing together of the bituminous sand and about 20% of its weight of a one or two per cent. silicate of soda solution. This operation causes a marked change in the character of the bituminous sand. The solution is all taken up by the sand which changes from a black plastic mass to a brown granular mixture. The change to a brown color and the disappearance of the bonding action of the bitumen suggests that the bitumen becomes emulsified.

*The process is described in detail in Bituminous Sands of Alberta, Part II, by K. A. Clark and S. M. Blair, and in previous Annual Reports.

2. The second operation is the washing of the treated bituminous sand by a stream of hot water into a comparatively large body of hot water. The result is that sand and bitumen become completely dispersed through the hot water. The sand sinks and the bitumen rises as a froth. At the commencement of a separation run, it may be noted that the first bitumen to rise appears at the clean water surface as tiny specks which film out and show colors in the light. Apparently the bitumen is very finely dispersed. The production of such fine dispersion suggests that an emulsion is involved in the action. It might come about by the breaking of an unstable oil-in-water emulsion.

3. Separated bitumen rises to the surface of all plant water. It cannot be confined to one surface by baffle plates. The most of it appears on the surface of the body of water into which the treated bituminous sand is washed. But wherever this water is pumped or otherwise taken around the plant in such a way that it presents a surface, separated bitumen collects on such surface. This suggests that the plant water is of the nature of an unstable oil-in-water emulsion.

4. Plant water which has been allowed to stand and from the surface of which all bitumen has been removed still has a bitumen content which may amount to as much as 2%. This must be present in emulsified form.

Because of these indications of the role of emulsions in the mechanism of the separation process, it was desirable to make some study of the emulsifying action of waterglass on bitumen from the bituminous sands under conditions of concentration and temperature such as exist during the separation process. There was the hope that such an investigation would yield information which would throw such light on the process that ways of controlling it to give uniformly good separation would be revealed.

An investigation was carried through on rather broader lines than just indicated. The emulsification of kerosene containing small percentages of oleic and steric acid, by various brands and concentrations of silicate of soda, and at temperatures up to 85°C. was first examined. Sodium carbonate and sodium hydroxide were also used in place of the silicate of soda. Next bitumen was dissolved in the kerosene, in varying concentrations up to 100%. Also various substances, such as oleic and stearic acid and a number of metal soaps, were dissolved in the bitumen in small amounts. In each case the type of emulsion formed was noted, as well as observation about its appearance and stability. The result was a large amount of data which cannot be summarized, but which provides an excellent back ground for further studies.

The investigation showed that the treatment of separated bitumen by silicate of soda of various brands and in proportion and at concentrations and temperatures comparable to those of the separation process, results in the formation of oil-in-water emulsions, though not very stable ones. It would thus appear that when bituminous sand is treated with silicate of soda the tendency would be to emulsify the bitumen to an oil in water emulsion. This may be the principal action that liberates the bitumen from its adher-

ence to the sand surfaces. The fine sand should tend to break the oil in water emulsion, giving water and a water in oil emulsion in a fine state of division. The diluting of the original emulsion by washing the treated bituminous sand into the large body of hot water would also tend to break it with formation of finely divided water in oil emulsion. Whatever may be the exact mechanism, there is considerable evidence in support of the view that the treatment of the bituminous sand emulsified the bitumen, that the first emulsion formed is of the oil in water type, and that this subsequently breaks or inverts to water in oil emulsion.

The bitumen from the separation process always contains a very considerable percentage of water. This separated bitumen has always been regarded as a water in oil emulsion. But one might wonder whether the water were present as drops dispersed through the bitumen or as a system of films as is supposed to exist in a gel. This point was tested by making conductivity measurements. It was considered that if the water were dispersed through the bitumen, the separated bitumen should have a very high resistance comparable to that of dry bitumen. If, instead, there were a lattice structure of water extending through the wet bitumen, its resistance should be much lower than dry bitumen. The resistance of the separated bitumen in the improved conductivity cell used was too great to be measured by a simple Wheatstone bridge. The same was true for dry bitumen. A bitumen-in-water emulsion showed a resistance of 84 ohms, while the soap and starch solution used in making this emulsion had a resistance of 19 ohms. The evidence consequently indicates that the separated bitumen is an emulsion of the water-in-oil type and is not a gel.

LABORATORY STUDY OF SEPARATION PROCESS.

A laboratory, bituminous sand separation plant for studying the various factors influencing the efficiency of the process by small scale work, and results obtained with it, have been described in previous reports.* This plant was used again during 1928, and 135 experimental separation runs were made with it. Some significant results were obtained.

Previous work had revealed the following conditions affecting the efficiency of the separation process:

1. Weathered bituminous sand is not amenable to the separation process. Separation results are poor in proportion to the contamination of the bituminous sand with weathered material.

2. Silicate of soda is the most satisfactory reagent so far tried for treating bituminous sand for separation.

3. Thorough mixing and heating of the bituminous sand with treating reagent is required.

4. The range of temperature from 75°C. to 85°C. is the best both for treating and separating the bituminous sand.

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*Bituminous Sands of Alberta, Part II, K. A. Clark and S. M. Blair; also Sixth and Seventh Annual Reports of the Scientific and Industrial Research Council of Alberta.

The purpose of the work now described was to discover further conditions of a less obvious nature, but upon which uniform efficiency of separation may nevertheless depend.

Two improvements of procedure were introduced into this work. In the first place great care was taken to prepare a quantity of bituminous sand which was uniform throughout, of sufficient quantity for a long series of runs. A supply of about 700 lbs. of fresh bituminous sand collected from one stratum of an exposure was put through a meat mincing machine and then thoroughly mixed by shovelling it over several times. A second rather larger supply that had been mined at the same location, but from a succession of strata, was prepared in the same way. Analyses of a number of samples taken at random from each supply showed that a uniform composition throughout had been secured. These analyses are shown in Table I. In the second place, equipment was built for giving a uniform steady feed of treated bituminous sand with the laboratory plant. This consisted of a steam-jacketed hopper, of sufficient capacity to hold the charge used in one run, feeding into a power meat mincer with stuffer attachment, discharging through a T connection with the pipe down which the hot water stream flowed to wash the treated bituminous sand into the body of hot water in the separation box or tank.

TABLE I.

Results of Analyses of Samples taken at random from the two supplies of about 700 lbs. each of Bituminous Sand after thorough mixing for experimental separation runs.

Sample	Composition			Sieve Analyses of Mineral Matter			
	Water %	Bitumen %	Mineral Matter %	Retained on Mesh 48	Retained on Mesh 100	Retained on Mesh 200	Passing Mesh 200
First Supply	0.2	14.8	85.0	1.8	70.4	19.1	8.7
	0.2	14.6	85.2	1.8	71.5	18.2	8.4
	0.2	14.8	85.0	2.2	70.5	19.4	7.9
Second Supply..	0.3	11.6	88.1	0.5	34.1	55.6	9.8
	0.3	11.5	88.2	0.6	30.6	58.0	10.8
	0.3	11.4	88.3	0.7	33.2	56.1	10.0

Seventeen pounds of bituminous sand were used for each run. This was the maximum quantity that could be mixed properly in the steam heated Universal Kneading and Mixing Machine employed. The bituminous sand was free from weathered material. It was mixed to a temperature of 85°C. with the treating reagent dissolved in water. The plant water in which the treated bituminous sand was separated was kept at the same temperature. A stream of hot water flowing at the rate of 6 gallons per minute washed the bituminous sand into the separation tank. The quantity of water in which the treating reagent was dissolved was varied over a considerable range, but the only apparent effect was to cause a variation in the consistency of the treated bituminous sand. Consequently it was decided that the quantity of water that gave

the best consistency for feeding into the plant was the best quantity to use. The manner of adding the reagent and water was varied. It made no apparent difference whether the sand was added to the reagent or the reagent to the sand, or whether the reagent was a dilute solution in all the water used or a concentrated solution added to the sand and water during mixing. The rate of feed of treated bituminous sand was varied both deliberately and because of differences in consistency affecting the passage of the material through the hopper and feeding equipment. It amounted to from three to eight pounds per minute. The variation had no apparent effect on efficiency of separation. The bitumen content of the bituminous sand separated was varied from 6% to 21%, by adding to it either sand tailings or separated bitumen, without apparent effect on the efficiency of separation. It may be shown eventually that these various factors have an effect on efficiency; but in the work so far done, any effect they may have had has been overshadowed by more important factors.

Table II contains abridged data for a number of the runs made. The per cent. of mineral matter, calculated to a dry basis, remaining in the separated bituminous sand is the best analytical value for gauging the effectiveness of the separation. The percentage of water in the separated bitumen is also of special interest since the securing of a low water content is the principal problem of separa-

TABLE II.—RESULTS OF SEPARATION RUNS ON TWO SUPPLIES OF BITUMINOUS SAND.

Run No.	Composition of Separated Bitumen				Sieve Analyses of Mineral Content of Separated Bitumen				REMARKS
	Water %	Bitumen %	Mineral Matter %	Mineral Matter Dry basis	Retained on Mesh 48	Retained on Mesh 100	Retained on Mesh 200	Passing Mesh 200	
47	18.6	77.1	4.3	5.3	23.5	33.3	17.7	25.5	FIRST BITUMINOUS SAND SUPPLY
49	21.0	76.2	2.8	3.5	14.7	29.4	17.6	38.3	
50	16.2	82.0	1.8	2.2	19.0	28.6	19.0	33.4	
51	19.0	77.8	3.2	4.0	29.4	23.5	11.7	35.4	Consecutive runs with same plant water.
52	15.1	82.4	2.5	2.9	24.0	28.0	16.0	32.0	Bituminous sand treated with 0.4% sil. soda from
53	14.0	82.5	3.5	4.1	31.4	22.8	11.4	34.4	Crown Soap Co. Conditions constant.
59	23.1	71.5	5.4	7.0	25.5	23.5	7.8	43.2	Consecutive runs 0.2% "D" brand sil. soda.
60	19.0	78.5	2.5	3.1	14.3	21.4	14.3	50.0	0.6% " "
61	13.2	83.3	3.5	4.1	18.0	23.0	15.4	43.6	0.4% " "
62	28.3	66.9	4.8	6.7	17.5	22.1	12.8	47.6	0.2% "S" " "
63	31.3	63.7	5.0	7.3	22.6	22.6	13.2	41.6	0.6% " "
64	25.1	69.2	5.7	7.6	21.7	21.7	13.1	43.5	0.4% " "
65	25.6	69.3	5.1	6.9	28.7	23.8	13.6	33.9	0.2% "BW" " "
66	21.8	75.1	3.1	4.0	17.1	20.0	17.1	45.8	0.6% " "
67	26.1	68.7	5.2	7.0	21.8	23.7	10.9	43.6	0.1% " "
79	13.2	84.7	2.1	2.4	13.3	20.0	13.3	53.4	0.4% " "
80	13.0	84.6	2.4	2.8	21.2	24.2	12.1	42.5	
81	19.2	78.3	2.5	3.1	15.7	21.0	13.3	50.0	Consecutive, but 1% "BW" added to plant water.
82	12.3	86.0	1.7	1.9	8.0	16.0	12.0	64.0	Consecutive, but 0.2% $CaCl_2$ added to plant water.
68	25.4	69.5	5.1	6.9	19.6	21.5	15.7	43.2	Consecutive runs, 0.5% Na_2CO_3
69	24.5	70.0	5.5	7.3	26.4	20.7	11.4	41.5	0.1% "
70	33.8	61.1	5.1	7.7	5.3	17.6	15.7	61.4	0.8% "
90	19.8	74.7	5.5	6.9	1.2	38.4	43.0	17.5	SECOND BITUMINOUS SAND SUPPLY
91	23.9	71.9	4.2	5.5	2.0	36.8	30.6	30.6	Consecutive runs with same plant water.
92	20.0	73.4	6.6	8.2	2.3	48.8	37.3	11.6	Bituminous sand treated with 0.4% "BW" sil. soda.
93	20.0	74.5	5.5	6.9	1.6	41.3	39.6	17.5	Conditions constant.
94	29.8	67.4	2.8	4.0		20.0	20.0	60.0	Ditto, except for 1% $CaCl_2$ added to plant water for
95	27.6	69.0	3.4	4.7		32.5	30.0	37.5	Nos. 94 and 95.
127	20.0	78.3	1.7	2.1		43.8	37.5	18.7	0.4% "BW" sil. soda
132	19.1	76.9	4.0	4.9		39.1	34.4	26.5	0.2% " "
135	22.8	75.6	1.6	2.1		33.3	30.3	36.4	0.6% " "
129	18.3	74.9	6.8	8.3	4.1	55.1	30.6	10.2	0.4% "D" " "
130	31.7	62.0	6.3	9.2	1.4	42.3	33.8	22.5	0.2% " "
133	20.2	78.2	1.6	2.0		33.4	33.4	33.2	0.6% " " — Consecutive runs though not made in the order of listing.
128	26.5	66.5	7.0	9.5		38.6	44.5	16.9	0.4% "S" " "
131	36.6	53.6	9.8	15.4	0.5	39.2	38.7	21.6	0.2% " "
134	19.7	78.7	1.6	2.0		26.9	26.9	46.2	0.6% " "

All silicate of soda used was manufactured by the Philadelphia Quartz Co.
That obtained from the Crown Soap Company is solid SS brand dissolved to liquid form.

tion remaining to be solved. Runs Nos. 47 to 53 should have given the same separation results since they were all made under constant conditions so far as significant conditions are known. But, although the results fall within a narrower range than those of similar series in former work have done, they are still far from constant. And for this reason, it is hard to give weight to the variations in the other groups of runs where the brand and concentration of silicate of soda was varied or where sodium carbonate was used.

The mechanical analyses of the mineral matter in the separated bitumen indicates that there is a selective action in regard to what is retained by the bitumen. The mechanical analyses vary considerably and show marked divergence from those of the mineral matter of the original bituminous sand. Microscopic examination of the mineral matter from the bitumen proved the selective action very definitely. In the case of the runs from the first supply of bituminous sand, seventy-five per cent. of this mineral matter was coal. There was possibly two per cent. of lignite in the mineral matter of the bituminous sand. It was also noticed in the case of the larger sized particles that could be seen individually, that there was a selection of material other than quartz. Coal was not present to nearly the same extent in the case of the second supply of bituminous sand and so did not affect the composition of the mineral matter retained by the bitumen so much. There was a concentrating of coal and particles of other material than quartz, however, as well as an accumulation of material finer than 200 mesh.

The variations in water content of the separated bitumen are puzzling. It should be explained that the water content is not that of the bitumen as it first separates. The determination is made on the bitumen after it has cooled, stood for a day or more, and the water which separates of itself on cooling has been poured off. It may be that the way in which the bitumen cools, depending on room temperatures for instance, may have a subtle influence on the amount of water that separates. It can be noted in Table II that there is a strong tendency for high water and mineral matter content of separated bitumen to go together. Consequently, if the water content is subject to some extent to chance, there should be a corresponding chance variation in the mineral matter content of the separated bitumen. The separation of water from the bitumen on cooling will receive systematic study as soon as there is opportunity.

An important point brought out in the recorded results and substantiated by many more runs not recorded is that the addition of such reagents as calcium chloride to the plant water does not interfere with the efficiency of the separation. Instead, there appears to be an improvement. The purpose of adding these reagents is to precipitate the silicate of soda and suspended silt and clay which accumulate in the plant water. Once precipitated, this material can be settled out and eliminated. The practical significance is that the plant water can be kept clean and the necessity of throwing away large quantities of hot water avoided. The adding

of calcium chloride in the present series of runs has not had the effect of causing a reduction in the water content of the separated bitumen. Such effect was noticed in former work.*

The results shown in Table II reveal two features which have been characteristic of all separation studies so far made. These are, first, that exceptionally good and rather poor efficiencies of separation occur without any apparent reason, and, secondly, that there is a decided change in separation results with every change in the supply of bituminous sand used for making the runs. It was expected that the careful preparation of a uniform supply of bituminous sand sufficient for a long series of runs would eliminate erratic variations. While it did cut down the range of variation, variation is still pronounced. The results from the two supplies of bituminous sand are distinctly different. Better efficiency was secured with the first lot. Remembering that the mineral matter found in the separated bitumen from the first supply was about seventy-five per cent. coal, whereas that from the second supply contained in most cases less than twenty-five per cent. of coal, it is apparent that the separation of the bitumen from the quartz sand was much better in the case of the first supply. On the whole, the water content of the bitumen separated from the first supply is lower than in the case of the second supply.

It may be that it is unreasonable to expect uniformity of results from the separation process as it has been conducted so far; in other words, considerable variation in separation efficiency may be an inevitable accompaniment of the variable nature of the bituminous sand. This material is a mixture of bitumen which probably varies in its content of certain types of chemical bodies which have a subtle effect on the separation process, with mineral matter which varies widely both in the quantity of material other than quartz that is present and in the mechanical grading of the particles. No amount of mixing such as was resorted to in preparing the two supplies of bituminous sand used for the experimental runs can smooth out differences in the chemical nature of the bitumen. The bitumen is present as films around mineral particles and cannot be mixed. Very significant lack of uniformity could exist, especially when the bituminous sand supply comes from a number of strata. The mixing can give a uniform average for different quantities of material, but not absolute uniformity.

So far efficiency of separation has been sought for by proceeding directly from bituminous sand to a final separated bitumen product. The success achieved is very gratifying. There is no trouble in producing a separated bitumen containing less than 10% or even 7½% of mineral matter calculated to a dry basis. But so far it has been impossible to conduct the process so that the better results of two or three per cent. of mineral matter are always obtained. Probably constantly low mineral and water content will be secured only by the devising of a second clean-up operation applied to the crude separated bitumen. With most of the sand eliminated, there is then opportunity to mix the bitumen to a uniform composition and also to add to it reagents which study may show to be effective in leading to a final, uniform, and satisfactory product.

*Cf. Seventh Annual Report of the Scientific and Industrial Research Council of Alberta, p. 41.

SOIL SURVEY OF DISTRICT ADJACENT TO LESSER SLAVE LAKE BETWEEN SMITH AND HIGH PRAIRIE.

By F. A. Wyatt.

The territory covered by this survey is located to the south of Lesser Slave Lake between Smith on the east and High Prairie on the west. It extends as far south as township 68. This gives a maximum distance of 30 miles from the E.D. and B.C. railway, with approximately one-half of the surveyed area within the boundaries of the Lesser Slave Forest Reserve.

This area lies well within the wooded soil belt of Alberta. The greater part of the entire area is or has been heavily wooded, and much of the soil belongs to the poorer phase of the wooded soil group. The entire area is characterized by the abundance of muskegs, many of them quite large in extent.

The surface of the surveyed area is in many places rough and hilly, with the topography unsuited to cultivation. The roughest topography is found within the boundaries of the Lesser Slave Forest Reserve. The more desirable topography such as that suited to cultivation is found near the lake and bordering the mouths of the streams, and is rather limited in extent, especially for the eastern half of the area. The best topography in general coincides with the best soils. The northwest quarter of the area contains the greatest amount of land with suitable topography, and it is here that the greatest amount of settlement is to be found.

The best soils are those found in the parkland area. These occur along the streams or as deltas where the streams enter the lake. From the standpoint of fertility they are all that could be desired, but in some instances they could be improved by drainage. They are designated A soils. Most of the A soils are in the Indian Reserve or owned by farmers; many of them are already occupied. The soil of these areas vary from sands to clays, but in general they belong to the heavier classes such as silt loams, clay loams, and clays. The parkland soils of the Lesser Slave Lake Districts are in the same class as the better soils in the Edmonton District, in so far as plant foods are concerned. The wooded soils of this same area contain only about one-third as much nitrogen and about five-ninths as much phosphorus as the parkland soils.

The wooded soils constitute about 87 per cent. of the surveyed area. These contain small areas of the better phase of the wooded soils which are designated first class. They are generally heavily wooded, and the cost of clearing would be rather great. The topography is desirable and the soil is good enough to insure satisfactory crop yields. The second class wooded soils are more extensive than the first class. In the case of these second class soils the clearing is likewise expensive, but the soil and topography are not as desirable as in the case of the first class areas. However, it is thought

that the second class soils are sufficiently fertile to supply permanent homes.

The third class wooded soils constitute far the largest part of the surveyed area. They are heavily wooded; the topography is generally undesirable and the soil is relatively poor. Even the better parts should not be settled until the demand for such marginal land is sufficiently urgent. At the present time they are more valuable as timber areas, and to a lesser extent as grazing areas, than as farming districts. Much of this class of land could never be settled as the topography is too rough and broken for cultivation.

The muskeg and swamp areas contain 71,000 acres. Many of these soils are very poor, but in a few local areas the soil is good. They would all require drainage as well as clearing, and are not suited to immediate settlement.

NATURAL GAS RESEARCH.

By E. H. BOOMER.

In this, the first report on the chemical researches leading to the utilization of the natural gas of Alberta, only the chemical phases of the subject will be discussed. The amount of natural gas available, its distribution, and its wastage are well known. The work done to date will be outlined briefly. Generally, it is planned to continue each research that shows promise, and there are some problems not yet attacked that will be investigated as soon as time and facilities permit.

All experiments so far have been carried out on gas from the Viking field. It is proposed to continue the work with gas from the Turner Valley. The Viking gas is dry, sulphur free, and contains about 93% methane, 3.5% ethane, and 3% nitrogen, together with a few tenths of one per cent. carbondioxide. The results obtained are directly applicable to gases from other fields in Alberta that are sulphur free, or to such gases when they have been freed from sulphur. The higher percentage of ethane and the small amounts of propane and butane present in Turner Valley gas, for example, will introduce differences in degree rather than of kind. The presence of higher hydrocarbons will also make certain processes economically practicable which are not so with the Viking gas.

The experiments can be divided conveniently into five parts. In each part the work done will be outlined and future work indicated. The chemistry of the simpler hydrocarbons is a field open to a great deal of research, having been somewhat neglected in the past.

(1) *Thermal Decomposition.*

This work was done with two objects in view: the determination of the methane-carbon-hydrogen equilibrium, and the use of natural gas as a source of lampblack, hydrogen or oils. Temperatures up to 1100° Centigrade and space velocities up to 6000* were used on many different materials. The equilibrium was completely worked out over metallic catalysts. Lampblack suitable for rubber compounding is obtainable, with hydrogen containing less than 2% nitrogen as impurity. By another process, approximately 3.5% of the gas may be converted into organic compounds. These are largely napthalene, benzene and a tar soluble in sulphuric acid, together with some finely divided carbon. The gas left over contains about 20% hydrogen, 7.5% olefines (largely ethylene) and unchanged methane. This gas has a lower calorific value than natural gas, but is a better fuel from the point of view of ease of ignition and speed of combustion. By recirculation of this gas, a further yield of organic compounds may be obtained with a small increase in ethylene content. Natural gases containing more of the

*A "space velocity of 6000" means that 6000 cu. ft. of gas per hour could be treated for each cubit foot capacity of the reaction chamber.

higher hydrocarbons would yield more oils and ethylene. The ethylene is of particular interest as a starting point in the manufacture of alcohol and glycol. For the production of oils this process is not so efficient as that of Wheeler (British Patent 309455), who adds small amounts of air and steam to the gas entering the reaction chamber.

(2) *Incomplete Oxidation.*

This is a subject that has been widely investigated and in which considerable activity exists at the present time. It is conveniently divided into two parts:

A.—*Oxidation direct to organic compounds.* Oxidations have been carried out with and without catalysts at temperatures from 70°C. to 1100°C. The catalysts examined have ranged from inert refractory materials to the most active oxide catalysts, and include metals and one gas. It is difficult to produce compounds other than the oxides of carbon, hydrogen, and water. Small yields of formaldehyde and traces of methanol are readily obtainable, up to 3%, and momentary high yields occur. Control is difficult and it is doubtful if anything of commercial importance will be discovered. The use of gaseous catalysts in the manner of Layng and Soukop, Bibb and Lucas, and the use of high pressure, show promise. The methods of Bone and Wheeler, using solid catalysts, have only emphasized the difficulties of getting anything other than the first mentioned gases.

B.—*Oxidation to carbon monoxide, carbon dioxide and hydrogen.* In this part of the problem the equilibria between methane and air or oxygen, methane and carbon dioxide, methane and steam, carbon monoxide and steam, carbon monoxide and hydrogen and oxygen have been investigated over the complete range of temperatures.

A process has been developed to produce water gas rapidly and simply. The water gas may be used to produce methanol by the well known commercial process. Air or oxygen or mixtures of them may be used to produce water gas of any desired nitrogen content within limits. By adding steam and passage over a second heated catalyst the carbon monoxide is changed to the dioxide and easily removed. This leaves a nitrogen-hydrogen mixture very suitable for ammonia synthesis and gives carbon dioxide as a by-product. The Fischer process of producing oils and oxygenated organic compounds from water gas has been investigated, but shows little promise, and is not comparable with direct thermal decomposition of natural gas. Experiments are in progress looking for a catalyst to produce ethyl alcohol from water gas. The results to date do not warrant more than the statement that the search is worth continuing. The purely scientific results in the realm of catalysis are of great interest.

(3) *Natural Gas as a Hydrogenating Agent.*

A high pressure laboratory is in course of equipment to investigate high pressure chemistry. The principal problems will be the use of natural gas as a hydrogenating agent in the liquefaction of coals, and the reduction of the carbon-hydrogen ratio in tars and

oils. The direct conversion of natural gas to oils under pressure is an interesting possibility and quite compatible with theory. The search for ethyl alcohol catalysts will be transferred to the high pressure stage just as soon as conditions warrant. Many other researches are planned for investigation at high pressure and temperature with the use of natural gas, or an easily prepared derivative of it, as their main feature.

(4) *Chlorination.*

This is a subject in which no work has yet been done in Alberta. Considerable work has been carried out at other places and more work should be done. The hydrocarbons in natural gas are easily chlorinated, but it is difficult to control the reaction to give the chlorides desired. All or any of the hydrogen atoms may be replaced by chlorine. Hydrochloric acid is a product of the reaction. Other products such as monochlor methane and ethane and dichlor ethane are valuable as sources of the corresponding alcohols and glycol, whilst carbon tetra-chloride and chloroform have their own markets. Other chlorides, however, make up a large percentage of the products, and either must be suppressed or must have processes developed to utilize them. The controlling factor in any chlorination process will be the cost of the chlorine. Chlorination is particularly hopeful in this province in view of the northern salt beds, which could supply the chlorine. Caustic soda production from common salt is always accompanied by an equivalent chlorine production, but for which there is normally a much smaller market. Calcium chloride, in certain processes, would be a by-product of the hydrolysis of chlorides to form alcohols, etc., and is of use in its application as a road binding and dust laying material.

(5) *Sulphur Problem.*

Sulphur is present in nearly all the Alberta natural gases, and in particular in those "wet" gases treated for their naptha content and subsequently wasted. The sulphur is present in very large quantities, of which a considerable proportion is the so-called organic sulphur and is difficult to remove. The commercial methods which have been developed for removing sulphur from coal gas, etc., for domestic use or use in chemical plants can be employed without change with natural gas. The economics of applying these methods to such high sulphur gases as occur in Alberta must be investigated. Considerable quantities of sulphur could be produced as a valuable by-product of the purification process.

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